AGRICULTURAL ZOOLOGY

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BY

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WITH AN INTRODUCTION BY

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FORMERLY HON. CONSULTING ENTOMOLOGIST TO THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

TRANSLATED BY

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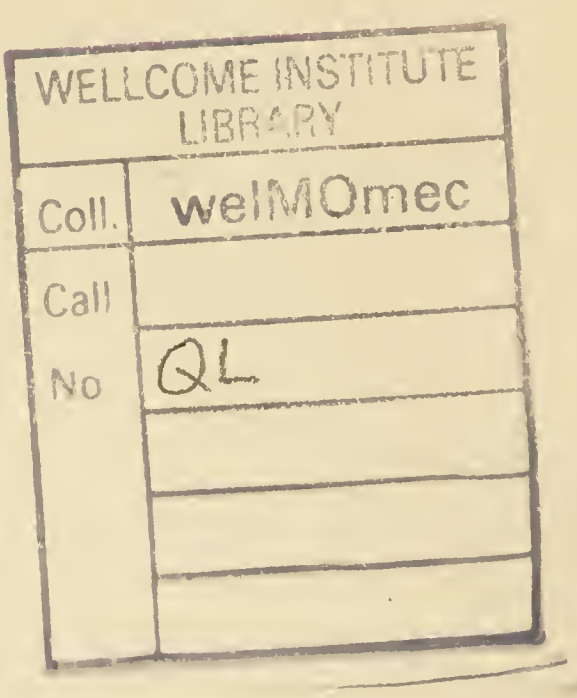

AUTHOR'S PREFACE.

THE present volume of the Thaer Library was undertaken with the intention of providing agricultural colleges with a condensed review of the entire animal kingdom, but treating in greater detail the animals harmful or helpful to agriculture. I have, however, omitted all reference to the domesticated farm animals, as in all such institutions these are treated of, not by the zoologist, but by the lecturer on stock-breeding. Although the book is not allowed to exceed a certain size, I have taken great pains to make it intelligible, and venture to hope that it may be found suitable for the *private use of the practical farmer*. To the farmer who wishes more exhaustive information, and desires a reference-book on the animal foes of agriculture, stock-breeding, horticulture, fruit-tree culture, and forestry, I venture to point out my

larger work, *Animal Foes and Friends*,* brought out last year by the publisher of this book.

It is hoped that the present volume may be found serviceable, both in the teaching of agricultural institutions, and to the practical farmer.

DR. J. RITZEMA BOS.

WAGENINGEN,
February, 1892.

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TRANSLATOR'S PREFACE.

AGRICULTURAL education is making such rapid strides in this country, that no apology is needed for translating a book which appears to fill a gap, especially as it is written by a well-known authority. Dr. Ritzema Bos has kindly allowed certain small alterations to be made which adapt the work to the requirements of British agriculture. Additions are indicated by square brackets, and small print employed in the case of some non-British animals. A few forms have been omitted for similar reasons. Constant reference has been made to the published works of Miss E. A. Ormerod, who has added to my obligation by writing an Introduction, and I also wish to acknowledge my indebtedness to Mr. J. H. Salter, B.Sc., and Mr. J. Dawson Roberts, M.R.C.V.S., for kind help given by them.

J. R. AINSWORTH DAVIS.

ABERYSTWYTH,
May, 1894

INTRODUCTION.

By request of Professor Ainsworth Davis, the skilled translator of this "handy-book" on "Agricultural Zoology," I add some words of introduction; and I have especial pleasure in so doing: not that any observations of mine can add value to the work of the well-known author, but because, having myself had the advantage for many years of colleagueship, and important help in my own work from the assistance of Dr. Ritzema Bos, I am well acquainted both with his extensive knowledge and also his scrupulous care in observation, and I believe that this abstract of his larger work, now given in a form in which it is available for general use, will meet a great need.

We have long wanted a book, plain in wording, and of moderate size, dealing with the wild animals or animal infestations generally which occur in connection with farm life—a manual, in fact, which, whilst suitable for the use of agricultural students and teachers, should at the same time not be too technically

scientific to be intelligible to practical farmers or to general readers.

In the pages of the present volume a very serviceable amount of information will be found to be embodied. So far as can be arranged in the limited space the chief characteristics of the main divisions of the animal kingdom are given, from the *Vertebrata* —including descriptions of some of our most notable forms of what may be popularly described as beasts, birds, and reptiles,—to the *Arthropoda*, including information on a most serviceable amount of insect infestation; also regarding Mites, Ticks, etc. These are followed by the *Vermes*, including, among other families of the *Nematoda*, the eelworms which cause so much injury to crop growth; and these are followed by the intestinal tape-worms and the fluke.

The fourth sub-kingdom, that of *Mollusca*, includes, besides snails and slugs, various kinds of shell-fish; and the lower sub-kingdoms—including *Echinodermata*, which may be typified by star-fishes and sea urchins, the *Cœlenterata*, or Zoophytes, and the *Protozoa*—will be found to be just entered on sufficiently to show their place in the scale.

The clear descriptions, made still more instructive by the numerous and good figures, will speak for themselves to all readers; but I should like to add a few lines to point out the serviceableness of a handbook in which the reader may turn at pleasure to the history of any common farm animal—as a weasel or a vole, a

wood-pigeon or a pheasant, a blind-worm or a common frog. And, in regard to the insect infestations, to which it will be seen more than a hundred pages of the book are devoted, I can bear witness to the great amount of valuable information which I constantly derive myself from the study of the writings of Dr. Ritzema Bos on this subject; and I trust this little manual of "Agricultural Zoology" may take the place in our farm and school libraries which I believe it to be excellently fitted to fill.

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Torrington House, St. Alban's,
May 24, 1894.

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INTRODUCTION.

I. Subdivision of the Animal Kingdom.

THERE are animals so like one another that they are given the same name. Such animals are ranked in the same *species*. Animals which differ so much that they have to be referred to different species, but which notwithstanding agree in the majority of their characters, especially the most important ones, are placed in the same *genus*. Hare and rabbit, or horse and donkey, are reckoned as different species of the same genus. Genera resembling one another are united into a *family;* thus, the pine marten and the beech or stone marten both belong to the *Marten genus* (Martes), while the weasel and stoat are different species of the *Weasel genus* (Mustela); but these two genera are so similar that they are both placed in the same family, *i.e.* the *Weasel family* (Mustelidæ). Nearly related families together build up an *order*. Thus, the Weasel family, Dog family, Cat family, etc., collectively constitute the *order of Carnivora*, characterized, speaking generally, by the same kind of teeth, claws, habits, and food. Several related orders are united into a *class*. Thus, for example, carnivorous animals (Carnivora), ruminating animals (Ruminantia),

gnawing animals (Rodentia), etc., constitute different orders of the *class of Sucklers* (Mammalia); while birds of prey (Raptores), pigeons (Gyrantes), and poultry (Rasores), are included in a second class, that of *Birds* (Aves). But both Birds and Mammals have a skeleton, of which the chief support is the backbone; on this account they are placed in a larger subdivision, the *sub-kingdom* of Backboned animals (Vertebrata); while snails are grouped under the sub-kingdom of *Molluscs*, millipedes and centipedes under that of *Jointed-limbed animals* (Arthropods).

In this way the animal kingdom is divided into *sub-kingdoms*, the sub-kingdoms into *classes*, the classes into *orders*, the orders into *families*, the families into *genera*, and the genera into *species*. Animals of the same species which differ from one another in more or less constant characters, belong to different *races* (domestic or geographical races).

There are many species of animals the external features of which are well known to ordinary folk, and which therefore possess a definite English name, but a much larger number, of the smaller forms especially, have no English name. It is, therefore, necessary to devise new names for these species. The English names, however, are liable to cause great confusion, since in different districts the same name is often applied to widely different animals. Besides this, distinct names have usually been given to successive stages in the life-history of the same form: "wireworms," for example, are the young state of the "click-beetle."

By using the scientific method of naming invented by Linnæus, confusion is made impossible. The Latin names of this naturalist have the great advantage that they not only give a perfectly distinct name to any particular species, but also at the same time show the genus to which it belongs. Each kind of animal possesses, in fact, two names; just in the same way as

every person possesses at least two names, a Christian name and a surname. The generic name comes first, and is, of course, common to all animals of the same genus. The second name is the specific one, and belongs exclusively to animals of the same species. The hare and rabbit, for example, are both included in the genus *Lepus*. The Latin name of the first is *Lepus timidus;* that of the second, *Lepus cuniculus*. Horse = *Equus caballus;* ass = *Equus asinus*.

II. Review of the Structure and Vital Phenomena of Animals.

I select as a point of departure the human body, and the bodies of domestic animals, because my readers are best acquainted with these.

The limbs consist, beginning on the outside, of skin, flesh, and bone. The same parts can also be distinguished in the head, neck, and trunk; but in these divisions of the body they enclose a cavity, the *body-cavity*, which, again, contains various parts ("organs"), which are not everywhere attached to the body-wall. Fig. 1 represents a longitudinal section through the body. The skin is represented by a line, flesh and internal lining are shaded, while the bones are black. These parts form together the *body-wall*. In front the body-wall encloses a cavity, the body-cavity (*Kh.*), which in Mammals is divided into two sections (thoracic cavity, *Bz.h*, and abdominal cavity, *B.h.*) by the *midriff* (diaphragm). In the thoracic cavity are found the lungs and heart (*H*), also most of the gullet or upper part of the gut; the abdominal cavity contains the remainder of the often much-coiled gut, which in one place widens into the stomach (*M*), also the kidneys, spleen, and parts connected with the gut (*e.g.* the liver). The cavities are bounded behind by the backbone (vertebral column), which is made up of many flattened vertebræ. The uppermost vertebra

supports the skull, which encloses a *cranial cavity* (*Sch.h.*) continuous with a *vertebral canal* bounded by the vertebræ. Cranial cavity and vertebral canal form together a second body-space, in which are contained the brain and spinal cord.

We will now consider the individual parts of the body, beginning with the *skeleton*. The axis of the skeleton is formed by the vertebral column (spine), which is composed of flat bones, the *vertebræ*. A vertebra usually consists of (1) the body, which occupies the front; (2) the arch, which possesses several projections or processes (neural spine, transverse processes, articular processes) and encloses the vertebral canal (*W.h.*). All mammals have seven neck or cervical *vertebræ* (Fig. 2, 1); while the number of the remaining vertebræ varies according to the species. The cervical vertebræ, which support the head, are followed by the dorsal or *thoracic vertebræ* (12 in man, Fig. 2, 2), and these by the strong loin or *lumbar vertebræ* (5 in man, Fig. 2, 3). Cervical, thoracic, and lumbar vertebræ are movable,

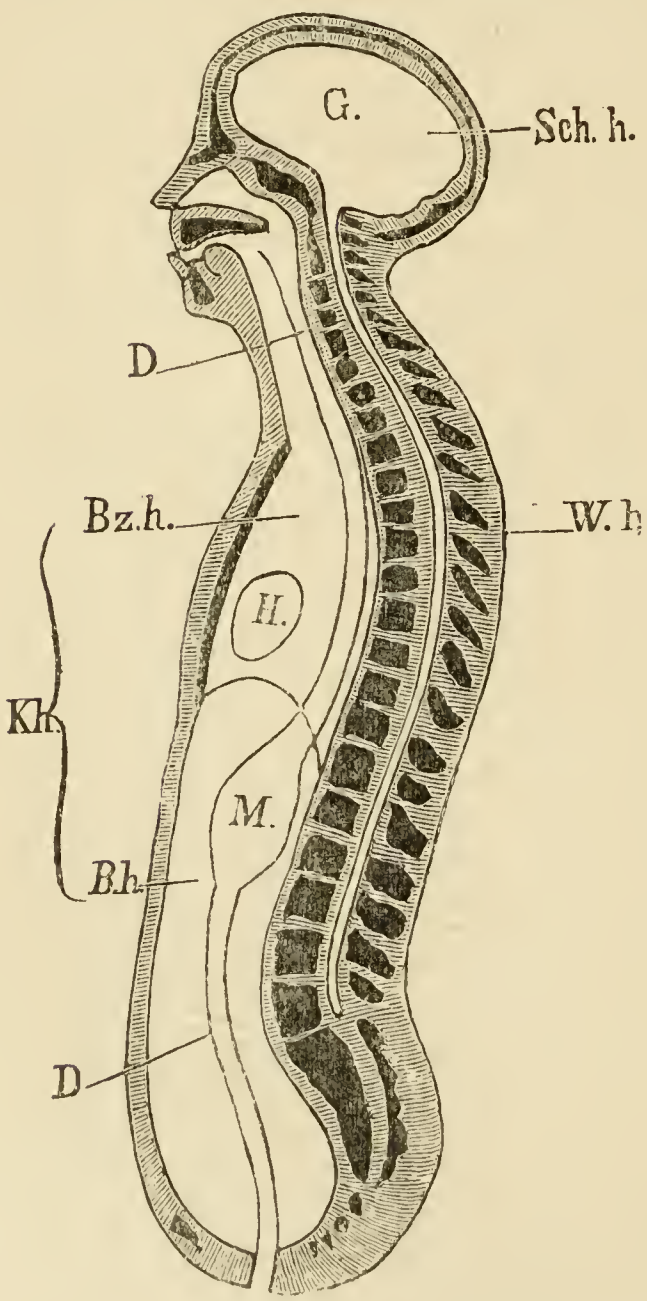

FIG. 1.—Schematic Longitudinal Section of the Human Body.

but, in man, the last-named are followed by five vertebræ immovably united together to make up the *sacrum,* and these again by tail- or *caudal vertebræ.* Man has four such vertebræ, all poorly developed, and fused with one another (Fig. 2, 5); but in many animals there are a large number, movably united to make up a tail.

The ribs, which in mammals bound the chest, are jointed to the thoracic vertebræ. Man has 12 pairs of ribs; each rib consists of a bony part behind and a gristly (cartilaginous) part in front. The so-called true ribs (Fig. 2, 14) [the upper pairs] are movably united with the breast-bone, but this is not the case with the false ribs (Fig. 2, 15).

In the head we distinguish the brain-case or *cranium,* and the skeleton of the *face.* The first contains the cranial cavity in which the brain is enclosed. We distinguish—2 frontal bones (fused together in man, Fig. 2, 6); 2 parietal bones (7); 2 temporal bones (8); an occipital bone (9) composed of several pieces fused together, perforated by the foramen magnum [where brain and spinal cord unite], and bearing two elevations or condyles [for effecting union with the backbone]; and the sphenoid and ethmoid bones which make up the base of the cranium. The facial skeleton consists of the framework of the jaws and palate, and, together with some of the cranial bones, bounds the cavities in which the eyes are contained (orbits), and the nasal cavities. It consists of the maxillary bones (Fig. 2, 12), the premaxillary bones (Fig. 3, 7,—in man these 4 bones are fused together into one piece), the nasal bones, the lachrymal bones, the ploughshare bone (vomer), the turbinated bones, the cheek-bones (or malars, Fig. 2, 11), the palate-bones, and the lower jaw (Fig. 2, 13). (The last originally consists of two symmetrical halves.)

The upper and lower limbs are built on the same type, and therefore consist of corresponding parts

(cp. Fig. 2). The more similar the functions of the two pairs, the closer their resemblance. In the ox they are much more alike than in man; in the bird, on the contrary, the similarity is much less. A distinction can be drawn in both limbs between the bony girdles (shoulder-girdle and hip-girdle), which serve for union with the trunk-skeleton, and the different subdivisions of the limbs themselves. I place side by side the parts of the arm and leg of man.

Arm.	Leg.
I. Shoulder-girdle, consisting of: Shoulder-blade (Scapula) (Fig. 2, 17). Collar-bone (Clavicle). Coracoid process (of Scapula).	I. Hip-girdle, consisting of: Hip-bone (Ilium) (24). Pubis. Rump-bone (Ischium).
II. Upper arm: Upper arm-bone (Humerus) (18).	II. Thigh: Thigh-bone (Femur) (25).
III. Fore-arm: Radius (19). Ulna (20).	III. Leg: Shin-bone (Tibia) (26). Clasp-bone (Fibula) (27).
IV. Hand: Two rows of wrist-bones (Carpal bones) (21). Metacarpal bones (22). Finger-bones (Phalanges) (23).	IV. Foot: Two rows of ankle-bones (Tarsal bones) (28). Metatarsal bones (29). Toe-bones (Phalanges) (30).

The differences between arm and leg are explained by their different uses. The bones of the leg, used to support the human body, are firmer and thicker, but less movable than those of the arm, which is employed in grasping. Consequently the union between the hip-girdle and the trunk-skeleton is firmer than that of the shoulder-girdle. The radius can rotate upon the ulna, so as to completely turn the hand over; a similar twisting of the foot would not be of use, and cannot be effected. The leg has a knee-pan (patella) (Fig. 31), with which there is no bone in the arm to correspond. In the foot the

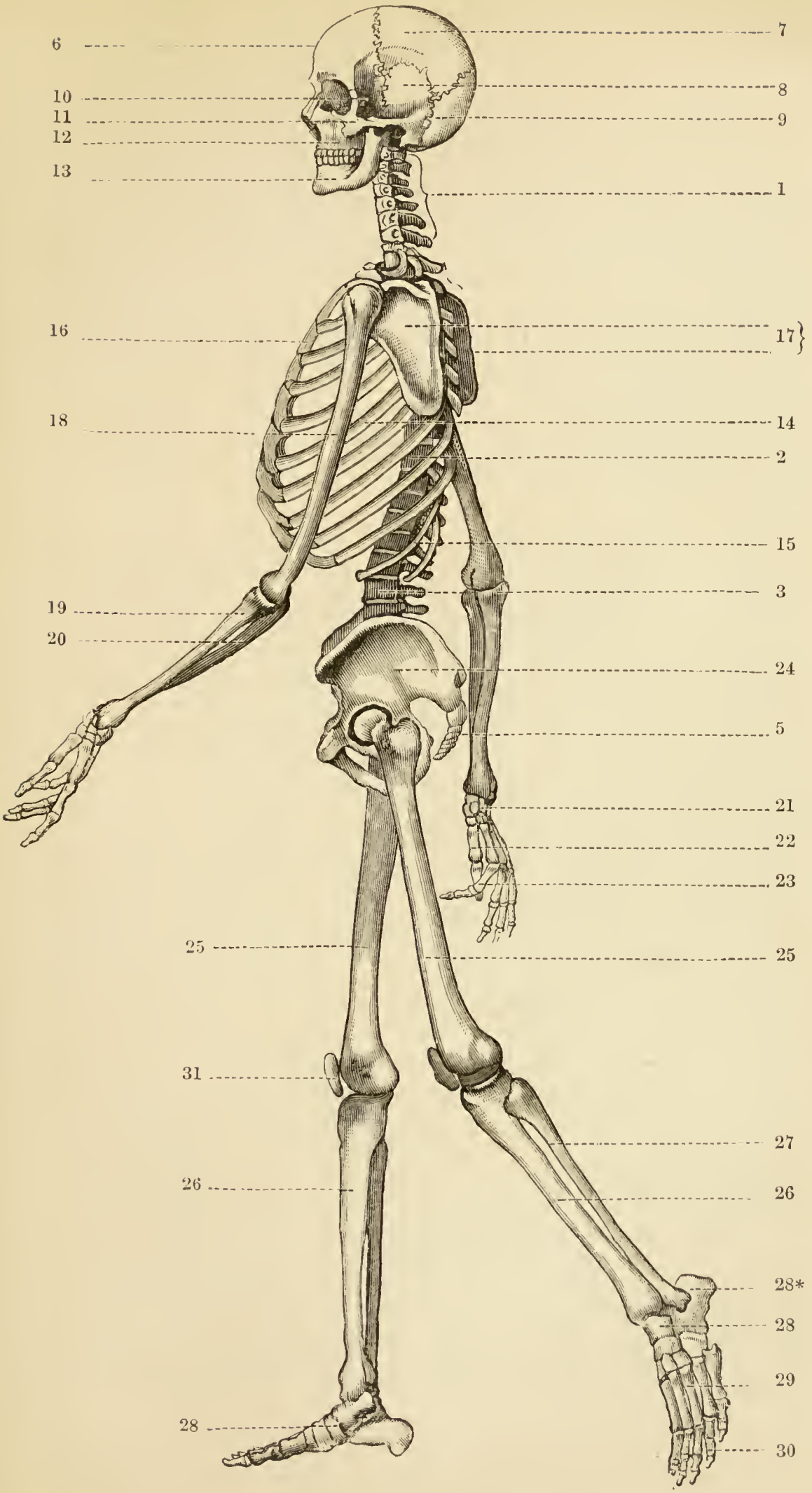

FIG. 2.—The Human Skeleton.

toes are short, and the remaining parts long; for instance, one of the tarsal bones, the calcaneum (heel-bone), is strongly developed and projects behind (28 *). In the hand, the digits are relatively long, and since the tip of the thumb can be made to touch the tips of all the fingers, are admirably adapted for grasping.

The number of fingers or toes is at most five, but may be less. The horse has a single digit to each limb; the ox, two well developed and two remaining as rudiments; the pig, two large and two small; while the dog has four toes in the hind foot, five in the fore foot.

Man walks on the sole of the foot. Some other animals (dog, cat) on the toes; others again (horse, ox, pig), on the tips of the toes. In the last case there is not simply a horny structure (nail or claw) on the upper side of the toe, but a hoof sheathing the whole of its tip. In many animals the thigh and upper arm are drawn close up to the body, so that the limbs appear quite different from those of man. (Compare Fig. 2 with Fig. 3.)

The bones are usually surrounded by flesh. This consists of a number of different pieces united together by a delicate, elastic, fibrous mass (connective tissue). The different pieces are termed *muscles*, each of which is again made up of a large number of muscle-fibres, all taking a longitudinal direction. Each fibre can contract, and a muscle becomes shorter and thicker by simultaneous contraction of all its fibres. The contraction and subsequent relaxation of muscles move other parts. There are some muscles, the *hollow muscles*, which surround a cavity, and by their contraction propel the liquid or solid substances found in their cavity. The heart, for example, is a large muscle of this sort, serving to propel the blood, while the hollow muscular coat of the gut moves on the contained food. Other muscles are fixed by their ends

to other parts of the body, which they move by their contraction. We distinguish between *dermal muscles*

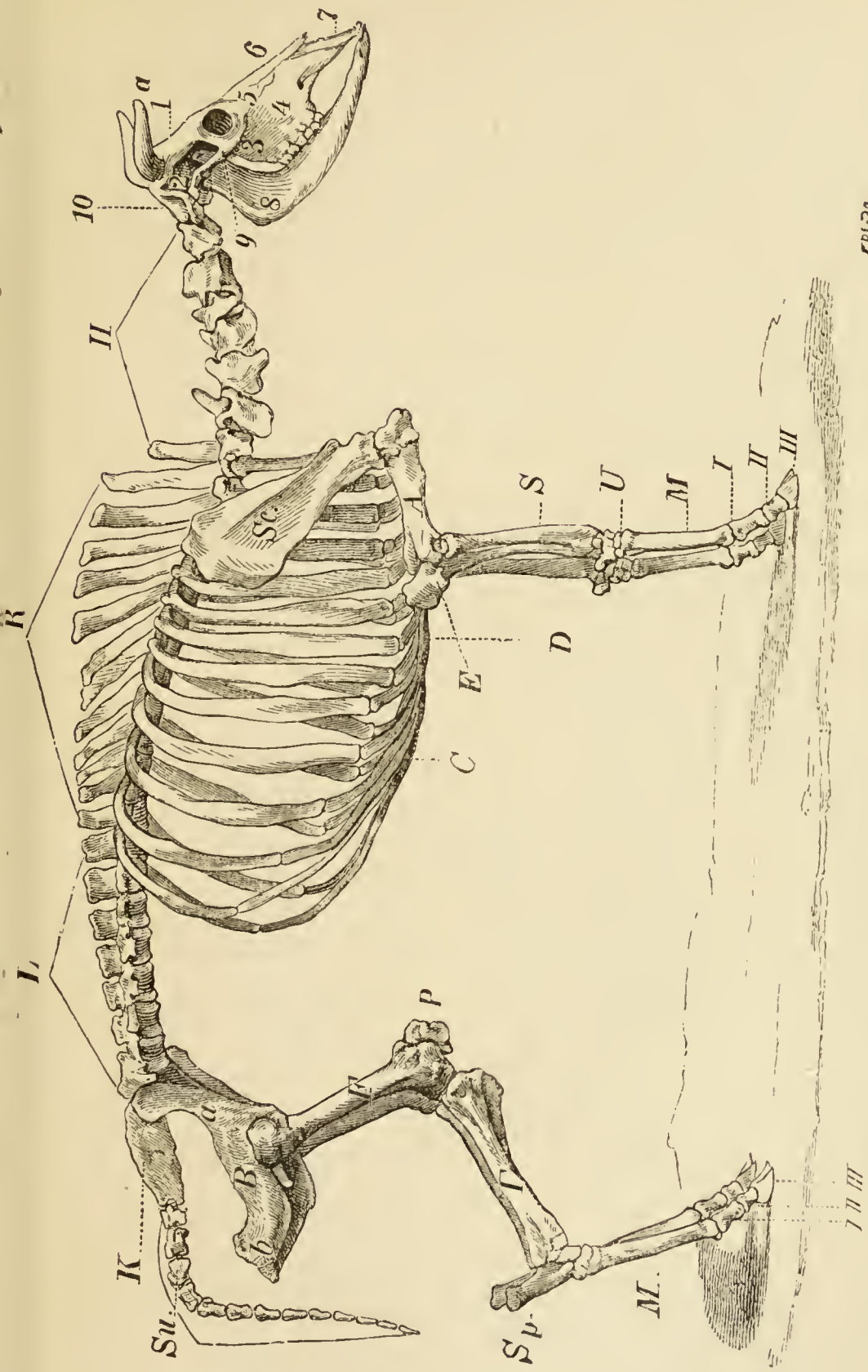

FIG. 3.—Skeleton of an Ox. I. *Skull*: 1, Frontal bone, with horn-cores, *a*; 2, temporal bone; 3, malar or cheek-bone; 4, maxillary bone; 5, lachrymal bone; 6, nasal bone; 7, premaxillary bone; 8, lower jaw; 9, orbit; 10, occipital bone. II. *Neck and Trunk*: *H*, 7 cervical vertebræ; *R*, 13 thoracic vertebræ; *L*, 6 lumbar vertebræ; *K*, sacrum; *Su*, caudal vertebræ; *C*, 13 pairs of ribs; *D*, sternum. III. *Fore Limbs*: *Sc*, scapula; *A*, humerus; *S*, radius; *E*, ulna; *U*, carpus; *M*, metacarpals; i., ii., iii., phalanges. IV. *Hind Limbs*: *B*, hip-girdle, *a*, ilium, *b*, ischium; *F*, femur; *P*, patella; *T*, tibia; *Sp*, tarsus; *M*, metatarsals; i., ii., iii., phalanges.

and *skeletal muscles*, attached respectively to the skin

or by one end to an integumentary structure (hair, feather, scale), and to parts of the skeleton. The animals which are devoid of any internal skeleton, the *invertebrates* (*i.e.* all animals except vertebrates), naturally possess no skeletal muscles. Examples of *dermal muscles* are those by means of which a bird erects its feathers (tail-coverts of peacock!), and those which enable a hedgehog to roll itself into a ball and stick out its spines. Each end of a *skeletal muscle* is connected with a bone. If such a muscle contracts the more easily movable bone is drawn towards the less easily movable one (Fig. 4). In order that the bones may be movable upon one another they are united together by joints.

According as muscular movements are, or are not, under the influence of the will, they are distinguished as *voluntary* and *involuntary*. To the latter kind belong the movement of the heart, and the movements of the muscles in the wall of the gut by which the food is made to progress.

To destroy the contractile power of a muscle it is not necessary to injure the muscle itself. Every muscle is related to a nerve, which sends its fine branches to the fibres making up the muscle. If we cut the nerve, the corresponding muscle loses its power of contraction. But the nerve arises from the *central nervous system*, which in vertebrates principally consists of the brain and spinal cord. The muscle will therefore lose its contractile power if the connection with

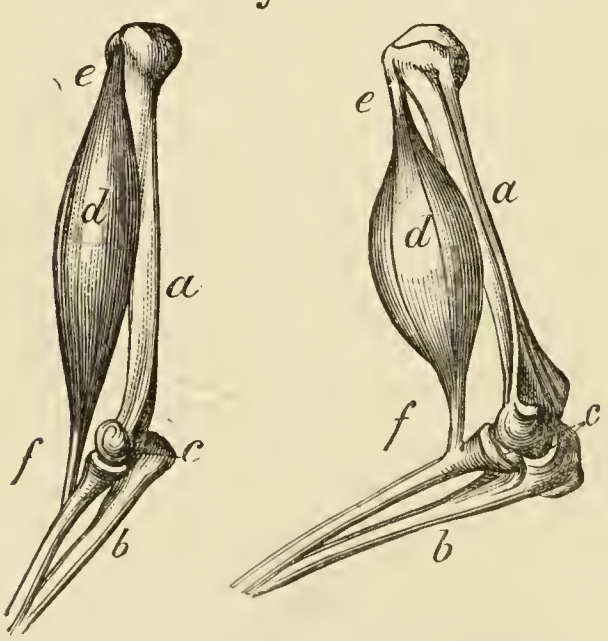

FIG. 4.—Bending of the Arm by Contraction of the Biceps Muscle. *a*, humerus; *b*, ulna; *c*, elbow-joint; *d*, biceps muscle; *e*, origin; *f*, insertion of the same. In the right-hand figure of the muscle *d* is contracted; in the left-hand figure it is slackened.

these central parts is broken. The true cause of movement resides in these parts. A sort of change, the essential nature of which is unknown to us, takes place in them, and is propagated along the nerve to the muscle, causing it to contract. The central nervous system is, therefore, the origin, the centre from which the order to contract proceeds; hence its name. The nerves which run from these central parts to the muscles are known as the *nerves of movement* (motor nerves).

There is still, however, a second group of nerves, the *nerves of sensation* (sensory nerves), which arise in the sense-organs (skin, mucous membrane of tongue, nose, ear, eye), and convey to the central nervous system the impressions they receive from the outer world by the aid of these sense-organs. In the appended diagram (Fig. 5), *C* represents the central

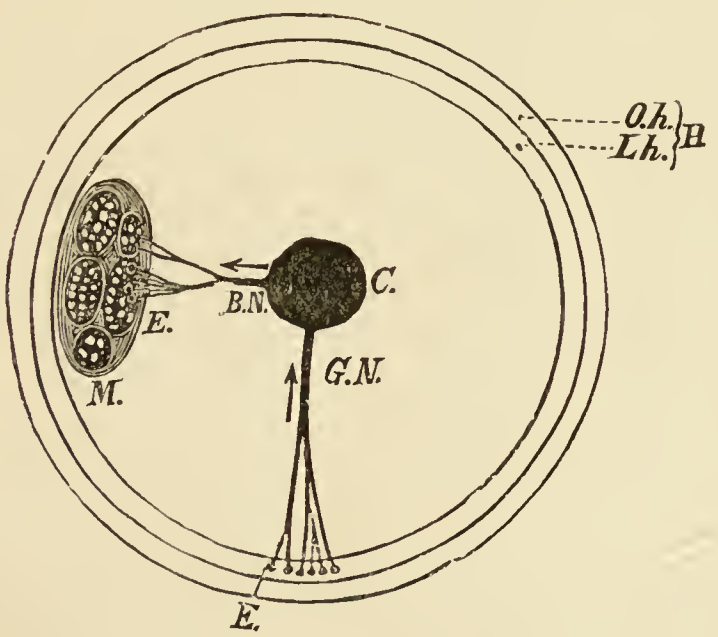

FIG. 5.—Diagram to explain the Action of the Motor and Sensory Nerves.

nervous system; *B.N.*, a motor nerve, branching in the muscle *M*; *G.N.*, a sensory nerve, which runs from the blood-bathed inner skin or dermis (*L.h*), underlying the outer skin or epidermis (*O.h*), to the central system. (The arrows indicate the direction in which impulses are conveyed along the corresponding nerve.

Men or animals lose in weight if they take no food. The reason for this is that certain substances leave the body either as gases (through the lungs), or as liquids (by the kidneys and sweat-glands), without a corresponding compensation. An animal or human being could not live without taking in fresh substances, which, according as they are solid or liquid, are known as food or drink. The different kinds of food and drink, which, with few exceptions (salts, water), are taken from the animal and plant kingdoms, cannot, however, *as such,* replace the gradually diminishing body-substance, for, to begin with, they contain useless matters, which pass out of the body in the *fæces* (dung). And even the nutritious parts of the animal and vegetable substances taken into the stomach, are not always in a form in which they can be used *at once.* Digestion, which in all the higher animals takes place in a *food-tube* (gut), serves to reduce them to a suitable condition, at the same time separating the useless matters. The action of several fluids (saliva, gastric juice, bile, etc.) secreted by glands, extracts the useful (nutritious) substances from the food and drink, converting them also into a suitable form. The smaller the pieces into which the food is separated, the better can this purpose be effected. In mammals the teeth serve to break down the food; in birds and many Invertebrates the same part is played by special secretions of the stomach or intestine provided with hard ridges.

So long as the nutritious food-stuffs remain in the food-canal, even though in a completely suitable form, they cannot nourish the body. And since waste of the substance of the body everywhere takes place, it is absolutely necessary that the food-stuffs should pass after digestion into a system of organs going to all parts of the body. This system is the *circulatory,* or *vascular system.* Food-stuffs enter it from the gut directly or indirectly, reaching it in the latter case through the *lymphatic* (lacteal) system.

The *blood* is the fluid into which the food-stuffs are taken up. It consists of an almost colourless liquid, together with an innumerable number of exceedingly minute blood-corpuscles.

The blood flows through the body in a system of tubes, or *blood-vessels*, which branch repeatedly, and at last become merged in the microscopic *capillary blood-vessels*. These capillaries are present in nearly all parts of the body except the epidermis and epidermal structures (hairs, feathers, scales, etc.). They have exceedingly thin walls, which present no resistance to the passage of the nutritious substances contained in the blood, so that these can be absorbed by those parts of the body which lie between the individual capillary vessels. The central organ of the circulation is the *heart*, an enlarged part of the vascular system, possessing thick muscular walls. By contraction of these, the blood is driven out of the heart (Fig. 6, *H*); and its exit is possible on one side only (*a*), as at the other side (*b*) there is a valve, which closes when the heart contracts. The vessel into which the blood leaving the heart enters is termed an *artery* (*S.A.*) It divides into several branches, also known as arteries, and the smallest arteries pass into capillaries, which again are connected with *veins*, which join larger and larger veins, until finally one or a few open into the heart (*A*).

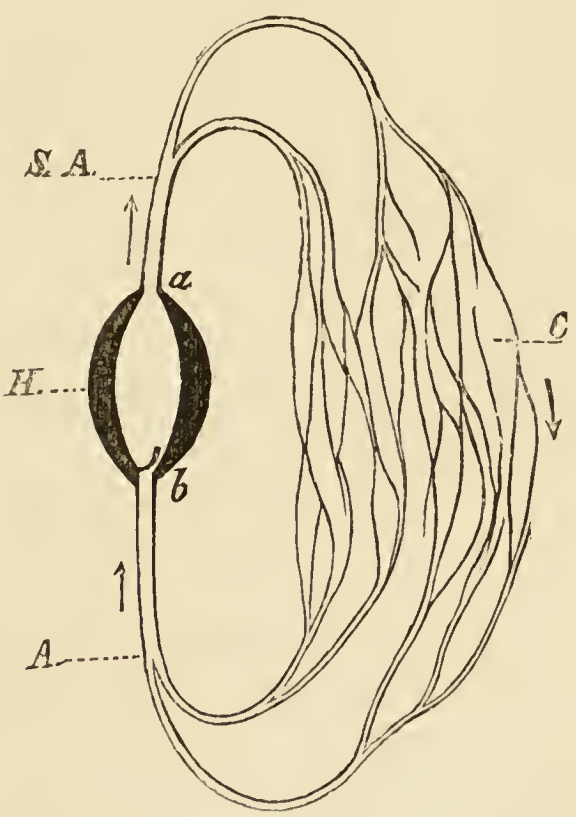

Fig. 6.—Diagram of the Course of the Circulation.

Since the blood in the course of its circulation gives up some of its nutriment to the various parts of the body, it would in the end become useless for the purposes of nutrition if it did not receive a fresh supply of food-stuffs from the gut, either directly or indirectly (through the lacteal system). But apart from this, the blood would ultimately become useless, and that very quickly, if it did not traverse the lungs, kidneys, and sweat-glands. It is well known to every one that a man or animal cannot live without air, or at any rate without a certain gas, *oxygen*, that is contained in air. This oxygen must be able to penetrate into the minutest particles of the body, and the blood, in the corpuscles of which it is contained, carries it everywhere. In the smallest particles (molecules) of the body an oxidation (combustion) of body-substance takes place, which not only causes an evolution of heat, but also renders the body capable of doing work. But if now the blood passes from the capillaries into the veins, it contains too little oxygen. And besides, it has taken up from the molecules of the body several substances, developed in those molecules, which would be fatal to the animal if they were not removed from the body. Now, when the blood streams through the lungs, it gets rid of the poisonous gaseous matter, and when it traverses the kidneys and sweat-glands it parts with the injurious liquid and solid substances. But in the lungs the blood takes up at the same time fresh oxygen ; and since in this way the air in the lungs becomes poor in oxygen, the *movements of breathing* (respiration) provide for the passage of a fresh supply of oxygen into the lungs. Only the higher Vertebrates breathe by means of lungs ; fishes and numerous aquatic Invertebrates breathe by gills, and insects by air-tubes (tracheæ).

While *Nutrition* is the life-process which shields the *individual* from death, Reproduction serves to maintain the *species*. It is familiarly known that

the offspring generally resemble their parents. But it is also a fact recognized by the stock-breeder, that a particular animal will not only transmit several of its *own* characteristics to its offspring, but perhaps also various characteristics of the grandparents or of animals belonging to still more remote generations, although these characteristics are not visible in the

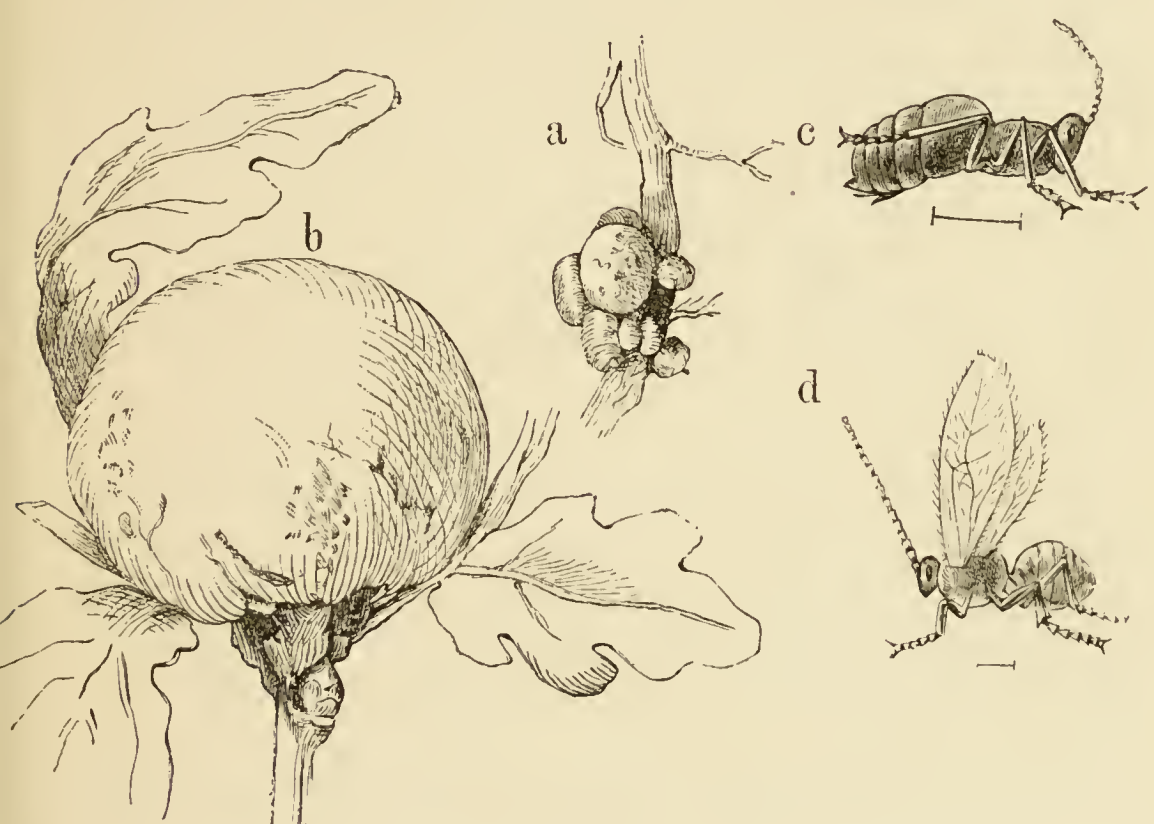

FIG. 7.—The Small-winged Gall-fly, *d* (*Andricus terminalis*), lays its eggs separately in the rootlets of oak. Root-galls (*a*) result from this, and inside of each of them a larva develops which, after a metamorphosis, becomes a relatively large, wingless gall-fly (*c*) known as *Biorhiza aptera*. This pierces the oak-buds in early spring, and lays a large number of eggs in them; from part of the bud is formed a large juicy gall (*b*), containing several larvæ, from which the small-winged gall-flies (*d*) develop. The species here represented exist, therefore, in two forms, *c* and *d* (Heterogeny).

animal which is actually breeding (*Reversion, Atavism*). Among insects and the lower animals there are species which, as adult animals, appear not in *one* form, but two or several. In this case, as a regular thing, the offspring does not resemble the parents, but the grandparents, great-grandparents, or

a still earlier generation. The older observers have placed the offspring and the parents, and sometimes the grandparents too, of the same animal species in different species, or even genera or families, until newer researches on the reproduction and development of these animals have proved them to belong to one and the same species (see Fig. 7 and explanation). The method of reproduction by which a species appears in two or several forms is distinguished as *heterogeny* and *metagenesis*, or *alternation of generations*. In the first (Fig. 7) sexually reproducing animals alternate with other sexual animals. It may be that these are of separate sexes, or else they may possess both male and female organs (*hermaphrodite*). In metagenesis a sexual generation regularly alternates with one or several generations reproducing asexually.

The animal kingdom falls (cf. p. 2) into sub-kingdoms or main divisions. Seven of these are commonly distinguished: I. Backboned animals; II. Jointed-limbed animals; III. Worms; IV. Molluscs; V. Echinoderms; VI. Cœlenterates; VII. Protozoa.

First Sub-Kingdom: **VERTEBRATA** (Backboned Animals).

The Vertebrate body possesses a bilateral or two-sided symmetry; *i.e.* it can be separated into two exactly corresponding halves, by a plane of division. The bilateral symmetry is strictly carried out as regards the external parts of the body, a single exception to this being flat-fish (plaice, flounder, etc.); but, on the other hand, it is more or less obliterated in the arrangement of the internal organs. In the Vertebrate body we find, as an axis, a vertebral column (backbone) made up of vertebræ, and traversed by the vertebral canal. As soon as this canal widens out

in the skull to the cranial cavity, the spinal cord, which it contains, merges into the brain. In addition to the cavity containing the central nervous system, and placed on the upper side (= dorsal side) of the animal, a cavity, the *body-cavity*, is found in the under side (= ventral side). It contains for the most part the organs of respiration, circulation, digestion, and excretion (Fig. 1), and in Mammals is divided by the diaphragm into *thoracic* and *abdominal cavities*. In all the other subdivisions of the animal kingdom the central nervous system is situated in the same cavity as the above-mentioned organs.

Various bones are connected with the vertebral column, and they serve for the attachment of muscles. The bones collectively constitute the skeleton, which is one of the most distinctive features of a Vertebrate.

The animals of this sub-kingdom never have more than four limbs, and their blood is red, while that of most other animal groups is colourless.

The structure of the heart in the various Vertebrates must also be noticed. In no Vertebrate is this organ so simple in structure as in the scheme given in Fig. 6; such an arrangement, moreover, would involve great difficulties. One great difficulty would be that while the blood was leaving the heart at *a* (Fig. 6), no fresh blood could enter, so that the blood in the veins would stand still. Even in the lowest Vertebrates (the Fishes) this difficulty is obviated, for where the main vein (or veins) opens into the heart an enlargement of this vein is found, where the blood can collect as long as the heart continues to contract. This expansion is also reckoned as part of the heart, and named the *auricle* (Fig. 8, *V.K.*), while the heart proper is termed the *ventricle* (*K.*). It is also easy to see that there must be a tolerably wide opening between the two chambers, so that as soon as the ventricle becomes flaccid the auricle can force blood into it. But there being such a wide aperture

between auricle and ventricle, one valve is not enough to make it impossible for the blood to pass back into the auricle during the contraction of the ventricular walls. There are two or three valves there (Fig. 8, *Kl.*), fixed by fibres to the wall of the ventricle. In order that the blood which is forced into the artery (*S.A.*) may not pass into the ventricle during its relaxation, there is another valve (not indicated in Fig. 8), at the base of the artery.

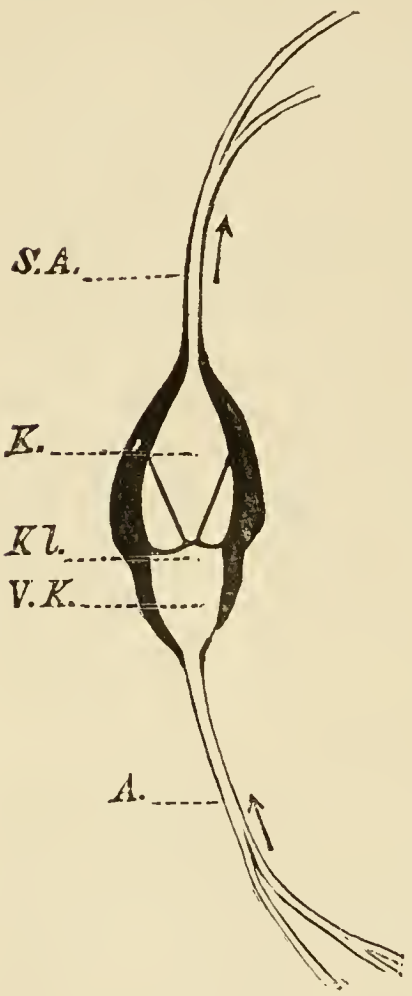

FIG. 8.—Diagram of the Heart in a Fish.

An arrangement like that so far described is found in fishes. The heart consists in them of an auricle, into which is returned the blood that has traversed the body, and of a ventricle which moves it on again. But the blood that has traversed the body is on that account poor in oxygen, and consequently unfit to be circulated again when it is returned to the heart. It is necessary for it to take up fresh oxygen before being circulated again. In fishes this difficulty is met by the blood, poor in oxygen, which flows out of the ventricle, first going to the *gills* and streaming through them. The gills consist of a very large number of small, thin-walled outgrowths arranged in regular rows on the firm gill-arches. The blood, poor in oxygen, passing out of the ventricle and through various arterial branches to the gill-filaments, takes up fresh oxygen as it streams through these from the oxygen dissolved in the water which constantly surrounds them. For this purpose a stream of pure water is regularly taken in by the mouth and

expelled again, right and left, through the gill-slits. The blood, having become rich in oxygen in the gills, is now once more fit for circulation through the body, and therefore flows out of the gill-capillaries into larger vessels, which finally unite into a single large vessel that carries the purified blood to the various parts of the body. In the arrangement of the heart here described there is the disadvantageous condition that the blood is obliged to traverse two sets of capillaries (gill and body capillaries). This is not an easy matter, for there is a great deal of friction between the blood and the walls of the capillaries, constituting a hindrance to its progress. The circulation of the blood in fishes is consequently very slow, and since the blood contains the oxygen which is used by the various parts of the body, oxidation goes on slowly in the body of a fish; hence the small amount of heat developed there. Since fishes almost immediately give off to their surroundings the small amount of heat which they develop, they have no constant body-temperature, varying in this respect with the temperature of the surrounding water. Such animals are termed *cold-blooded*.

In all other Vertebrates a more rapid movement of the blood is rendered possible by the insertion of a second heart, quite similar in every respect to the other heart, in the course of the blood between the respiratory organs and the body. The first heart drives the blood through the lung capillaries, and therefore corresponds to the fish-heart; from these capillaries the blood returns to the auricle of the second heart, and from the ventricle of that heart travels to the various parts of the body. When it has completed this course, it returns to the auricle of the first heart. Although these two structures work independently, they lie close together and make up a single organ. We do not therefore speak of two individual hearts, but of one heart with two halves.

The first half, which receives the blood, poor in oxygen, that is returned from the body, and sends it on to the lungs, lies on the right, and is termed the *right* half. The second half, which receives the richly oxygenated blood from the lungs, and pumps it to the various parts of the body, is termed the *left* half (Fig. 9 and explanation).

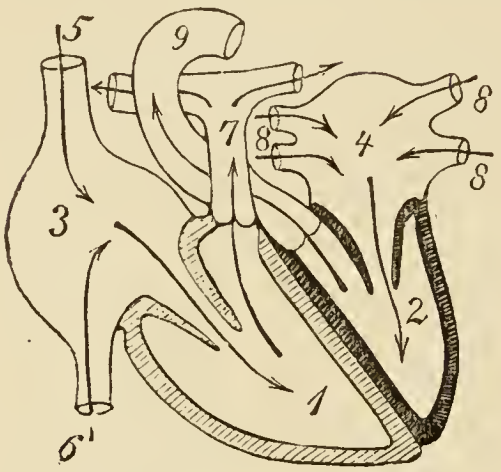

FIG. 9.—Diagram of the Mammalian Heart. 1, right, 2, left ventricle; 3, right, 4, left auricle; 5, superior, 6, inferior vena cava; 7, pulmonary artery forking into branches for right and left lungs; 8, the four pulmonary veins; 9, the great body-artery (aorta); the arrows indicate the direction of the blood stream.

In the arrangement just described, which is found in Mammals and Birds, the blood returning from the lungs is propelled with new force through the body, and therefore circulates very quickly, so that the various parts receive a relatively large amount of oxygen in a short time. It is therefore intelligible that Birds and Mammals develop more warmth than Fish. They possess a special, constant body temperature, somewhat different in different species, but usually lying between 98° and 104° Fhr., and they are called *warm-blooded* animals.

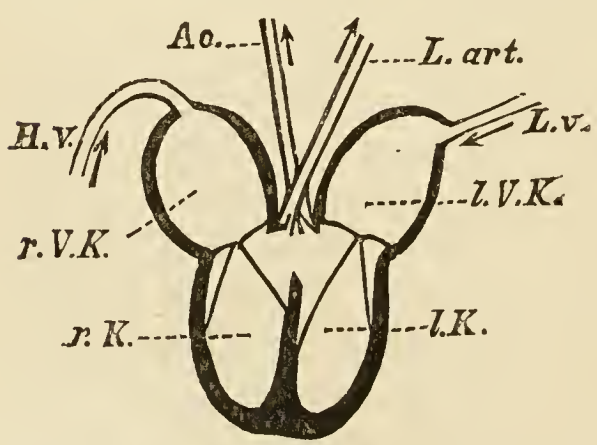

FIG. 10.—Diagram of the Heart of a Reptile. Between the right (*r.K.*) and left (*l.K.*) ventricles is a perforated partition. *r.V.K.*, right auricle; *l.V.K.*, left auricle; *H.v.*, vena cava, carrying back the blood which has traversed the body into the right auricle; *L.art.*, pulmonary artery; *L.v.*, pulmonary vein; *Ao.*, aorta.

In Reptiles (snakes, lizards, etc.), the two halves of the heart are not entirely distinct, since there is an opening in the partition-wall between the two ventricles. As a consequence of this, the poorly oxygenated

blood of the right half of the heart mixes with the richly oxygenated blood of the left half, the extent to which this mixing takes place being proportional to the size of the aperture. In Reptiles, therefore, the blood supplied to the lungs is not so poor in oxygen as it might be, nor, on the other hand, is the blood supplied to the other parts of the body completely oxygenated. As consequences of this: (1) respiration is feebler, and (2) the development of heat less than in Mammals and Birds (*i.e.* reptiles are cold-blooded), and (3) the chemical changes taking place in the body (the metabolism) go on more slowly than in warm-blooded animals, and we can understand why reptiles execute fewer movements in a given space of time.

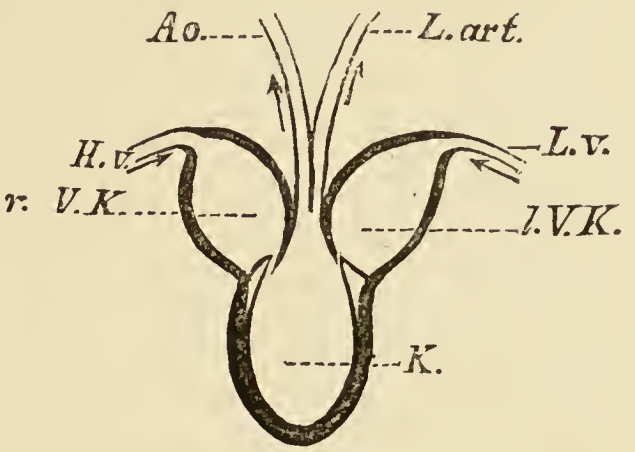

FIG. 11.—Diagram of a Frog's Heart. (The ventricle *K.* is quite undivided: compare Figs. 9 and 10.) Other letters as in Fig. 10.

In Amphibians (*e.g.* frog) the two ventricles are similarly connected, but the opening is still larger than in Reptiles, and the partition-wall may even be altogether absent. It follows, therefore, that the mixing of the two kinds of blood is still more complete, and that Amphibians, too, are cold-blooded.

The vertebrate sub-kingdom embraces the classes of I. Mammals; II. Birds; III. Reptiles; IV. Amphibians; V. Fishes.

CLASS I.: **MAMMALIA** (SUCKLERS).

Warm-blooded Vertebrates (p. 16), usually covered with hair, and bringing forth living young, that suck for some time after birth. The female is provided

with milk-glands on the thorax or abdomen, or both those regions.

Speaking quite broadly, the skeleton is like that of man, described on pp. 4–8. There are, however, great differences in detail. The cranium is relatively much smaller, and the bones of the face (especially of the jaws) are usually much larger than in the human skull. The number of the cervical vertebræ is seven in all Mammals, as in man; but the other kinds of vertebræ vary in number in the different species. The number of caudal vertebræ, for example, is very variable. As most Mammals go on all fours, their fore and hind limbs are much more similar than is the case in man. In many the thigh and upper-arm bones are drawn closely up to the body (horse, ox, pig). Mammals never have more than five fingers or toes, but may have fewer. The thumb or great toe is the first to disappear (hind foot of dog, fore and hind foot of pig). There may be only three (rhinoceros), two (ox,

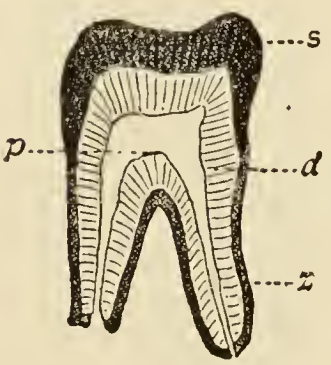

Fig. 12.—Vertical Section of a Human Grinding Tooth.

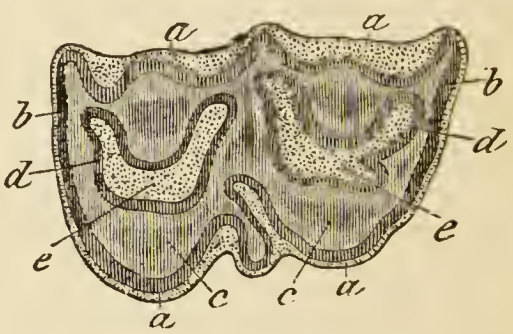

Fig. 13.—Crown of a Grinder of the Ox. *a*, cement; *b*, enamel; *c*, dentine; *d*, enamel; *e*, cement.

sheep), or one (horse) digit developed. In addition to fully developed digits, there are in many Mammals very small stunted ones ("dew-claws" of the stag).

There are also great differences in the way of resting the feet on the ground. Man and bear tread on the soles of the feet (plantigrade); dog and cat walk on the under side of the toes (digitigrade), not on the other parts of the feet. Ox, pig, horse, etc.,

rest while walking only on the tips of the toes, which are sheathed in hoofs (unguligrade).

The teeth of mammals are wedged into special sockets in the jaw-bones. The structure of a mammalian tooth is made clear by Fig. 12. We first distinguish a pulp-cavity (*p*), which in the living animal is filled with a substance supplied by a blood-vessel and nerve. This cavity is surrounded by the dentine (*d*), a hard substance which makes up the greater part of the tooth. Hard enamel (*s*) covers the whole of the crown in man and many animals, while in certain other forms it is found only on part of the crown. The root of the tooth is covered with cement (*z*), a bone-like substance.

All teeth in which the entire surface of the crown is covered by enamel only are known as *simple teeth*, while those into which the enamel only penetrates in more or less deep folds, leaving the rest of the crown uncovered, are known as *compound teeth* (Fig. 13). The structure of the teeth is related to the nature of the food. We distinguish three kinds of teeth in the same animal, which, however, are not all present in every species; these are the *incisors*, *canines*, and *grinders*. The first two kinds are changed; but only the anterior grinders, known as the *premolars*, are changed, while the hinder ones, the *true molars*, do not first appear as "milk" teeth, but rather later on with the other "permanent" teeth.

The following orders of Mammals are distinguished: I. Bimana (Man), II. Quadrumana (Apes), III. Carnivora (Beasts of prey), IV. Insectivora (Insect-eaters), V. Cheiroptera (Bats), VI. Rodentia (Gnawers), VII. Ruminantia, VIII. Solidungula, IX. Pachydermata, X. Cetacea, XI. Edentata, XII. Marsupialia (Pouched animals), XIII. Monotremata.

I shall deal here only with those orders which are of agricultural importance.

Order : **Carnivora** (Beasts of Prey).

In each jaw there are six relatively small incisor teeth; and, on each side of these, a large projecting canine, by which the flesh is torn from the body of the prey (Fig. 14). The premolars and the first of the true molars (the carnassials [1]) are strongly compressed, and have a cutting crown; their outer surface is completely covered with hard enamel. As the lower jaw is smaller than the upper jaw, and is only able to move up and down, not from side to side, the sharp crowns of the premolars, and especially those of the large carnassials, cut along one another, and divide anything coming between them as if with shears. The small molars which are usually found behind the carnassials have broad tuberculated crowns. The temporal (*i.e.* chewing) muscles are strongly developed, the general result of which is that the head is broad. The claws are very sharp in some of the families. The Carnivora are powerful animals, move very quickly, and are endowed with keen smell and sight.

The wild Carnivora living in Britain belong to the families of cats, dogs, and weasels.

Family : **Felidæ** (*Cat Family*).

Typical Carnivora with very large canines and carnassials, two premolars in each half of each jaw, one of the upper molars, but none of the lower ones, small and tuberculated. Tongue rough. Fore and hind feet five-toed. When not in use, the claws are drawn back (retracted). The Felidæ are digitigrade. Backbone very flexible, and with free power of movement. The Felidæ are bloodthirsty, nocturnal animals, many of which climb well, and spring upon their prey.

The group is specially exemplified by the **Domestic**

[1] The upper carnassials = last premolars.
The lower ,, = first molars.—Tr.

Cat, the parent stock of which is the Nubian cat (*Felis maniculata*), a native of Nubia and the Soudan. The **Wild Cat** (*Felis catus*) is larger than the common

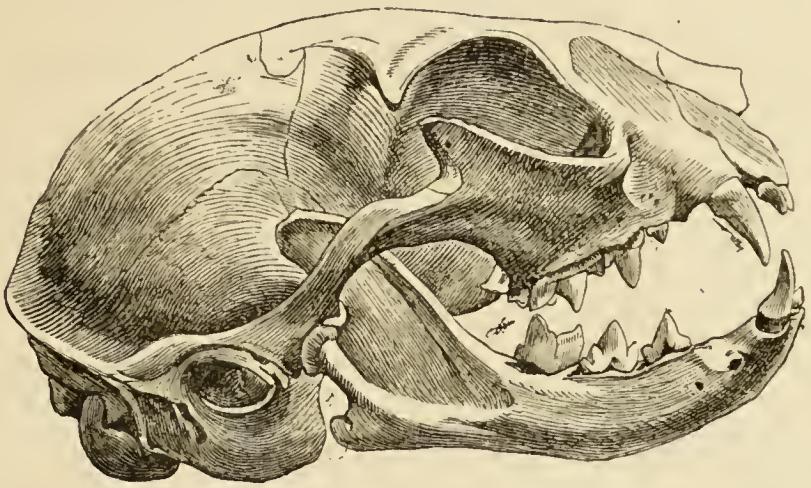

Fig. 14.—Skull of Domestic Cat.

kind, and has a thicker tail. Formerly it was tolerably common in Britain, but now only occurs in a few thinly populated districts.

The **Lynx** (*Felis Lynx*), found at one time in Germany, still lives in the Carpathians, and in Switzerland, but occurs more commonly in Scandinavia, Denmark, and Russia.

Family : **Canidæ** (*Dog Family*).

Head longer than in cats ; canines and carnassials relatively less developed. Two tuberculated molars on each side of each jaw. Claws not so sharp as those of cats, and cannot be drawn back (*i.e.* are non-retractile). Fore-foot five, hind-foot four toes. Tongue smooth.

The various races of the **Domestic Dog** belong here.

The wolf (*Canis lupus*) is no longer an inhabitant of Britain or Germany, but sometimes crosses the German frontier from Russia, Galicia, Hungary, the Alps, and the Ardennes, especially in winter, and preys upon the larger domestic animals.

The remaining example is—

The Fox (*Canis vulpes*).

This animal lives in an underground dwelling, which is either dug out by itself or else is a deserted badger-burrow. It kills roes, fawns, hares, and game-birds; in farms it preys on poultry and eggs. It never commits depredations in the neighbourhood of its burrow, for fear of betraying its hiding-place. Valuable services, however, must be balanced against the damage mentioned above, for it catches many rabbits, and also an enormous number of field-voles in the years when these become a pest. It also often eats insects (*e.g.* cockchafers), worms, and snails. In fact, the fox is perhaps generally of more use than otherwise to the farmer and forester.

Family : **Mustelidæ** (*Weasel Family*).

Elongated, slender; legs short; head small and flat; cranium elongated; tongue smooth. Five toes on each foot, with small, sharp claws. A tuberculated molar on each side in the upper and lower jaws. The weasels give out an offensive odour from stink-glands situated near the anus.

There belong to this family—

1. The **Pine Marten** (*Mustela martes*). Body up to twenty inches, tail up to ten inches long; fur brown, with yellowish wool-hairs; a yellow patch on the throat. Is found in thick woods, where it destroys small birds and squirrels; it also kills much poultry and game.

2. The **Beech**, or **Stone Marten** (*Mustela foina*). About as large as the preceding species; greyish-brown fur, with whitish wool-hairs; a white patch in the throat; chiefly occurs in the immediate neighbourhood of human dwellings, in barns, wood-stacks, etc.; kills a great deal of poultry, sometimes also wild birds, mice, and game.

3. The **Polecat** (*Putorius fœtidus*). Shining brownish-black, with yellow wool-hairs; somewhat smaller than

the stone marten; in particular, the tail is shorter and its hair is not so long as in the two preceding species. In the summer it lives in the open country, in hollow trees, or in the burrows of foxes and rabbits; in winter it settles down near human dwellings, where it lives in wood and under heaps of brushwood, hay-lofts, etc. In summer it may do more good by destroying numerous field-voles, water-rats, etc., than

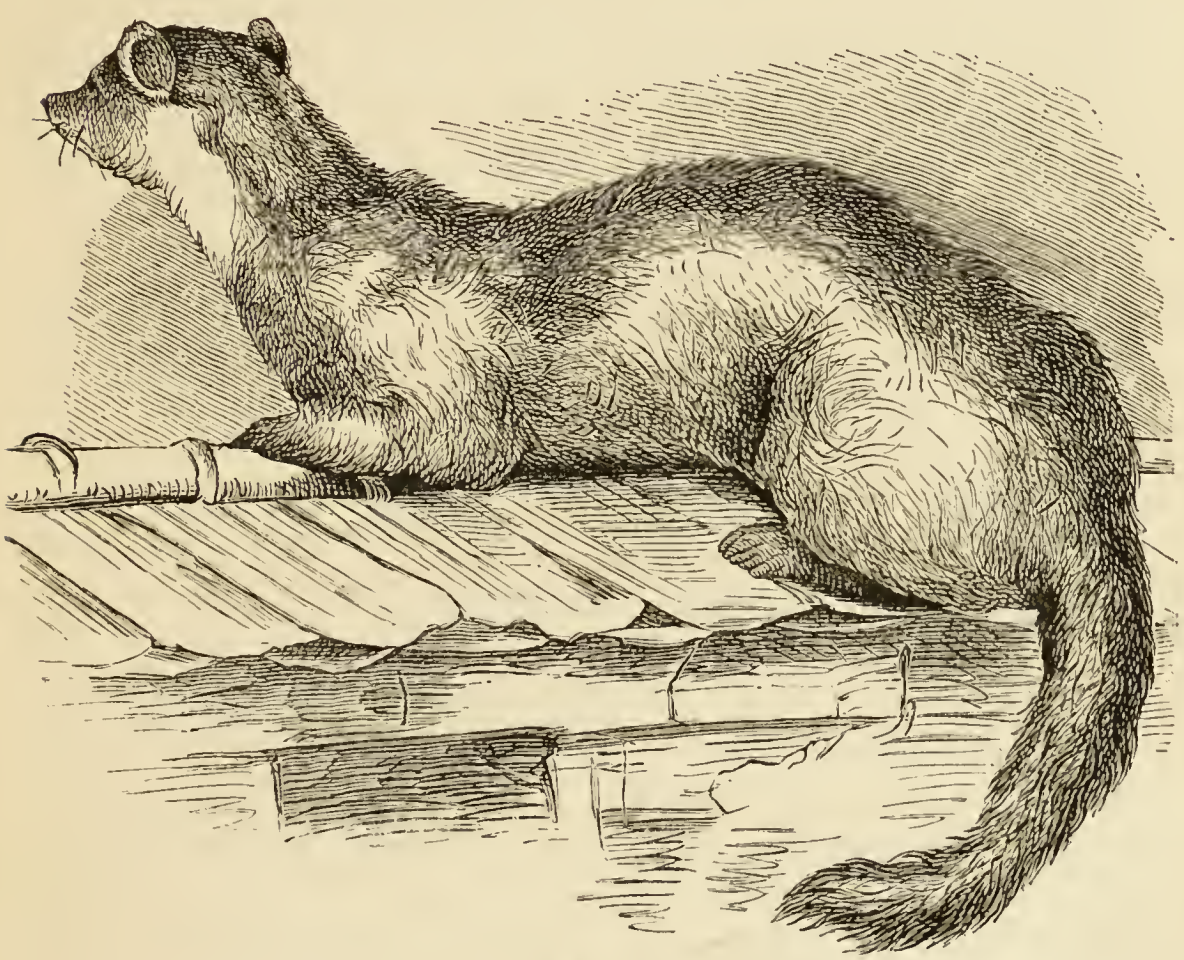

Fig. 15.—The Pine Marten (*Mustela martes*).

harm by devouring those singing birds which are favourable to agriculture; but in winter its undesirable visits to the fowl-house and dove-cot effect much injury. It kills the birds and devours the eggs, sucking without smashing them. In winter, too, it is very harmful to beehives, being fond of honey.

The **Ferret** (*Putorius furo*) is undoubtedly a short-legged variety of the common polecat, usually white in colour, and, when that is the case, red-eyed.

4. The **Stoat**, or **Ermine** (*Putorius erminea*). Body twelve inches, tail about three and a half inches long; slender; the body is scarcely broader than the head; tail longer than in the next species; summer fur, cinnamon brown above, white below; tail, cinnamon brown with black tip; winter fur quite white, but the end of the tail remains black. Mostly in fields, in the neighbourhood of plantations or woods; always abundant among sandhills, owing to the rabbits living there. The stoat usually follows its prey at night, stealing upon mice, rats, rabbits, hares, and song-birds; it is also sometimes very destructive in dove-cots and hen-houses. It must, however, be stated that the stoat is on the whole more useful than harmful.

5. The **Weasel** (*Putorius vulgaris*). Smaller than the stoat; head larger and thicker than the extremely slender, almost snake-like, trunk; legs short. The weasel is a very sharp little animal, and can easily pass along mouse-holes. Summer and winter coats alike—back brown, belly white. Its food chiefly consists of field-voles, also of rats and water-rats, young hares and rabbits, birds building near the ground, and also their eggs, which the weasel, by holding under its chin, manages to carry to its home; occasionally also lizards, blindworms, snakes, and frogs. The weasel does some damage in fowl-houses and dove-cots, and is also destructive to game. This, however, does not outweigh its very great use, since it is above all an untiring vole-catcher. When in any region the field-voles have multiplied excessively, an immigration of weasels takes place from surrounding parts. In years when there is a plague of voles the usual breeding time in spring is followed by another later on. A very large number of weasels may be found in a vole-infected district, and they thin out the mischievous rodents in a surprising manner. Nor are the weasels less useful in summer than in winter. They even follow under the snow

the voles which winter in the country, and the slaughter effected at this period must exert a great influence on the following season, when these animals recommence their injurious work, and a pair of them that have survived the winter may perhaps produce two hundred others before the end of the summer.

6. The **Mink** (*Putorius lutreola*) is as large as a polecat, and may be regarded as a sort of link between it and the others. Leg and ears short; skin smooth-haired, brown both on the back and the belly; chin, lips, and a small patch on the neck, white; tail about one-third the length of the body. In well-watered regions on the banks of rivers, lakes, and ponds. Eats water-rats, water-birds, frogs, salamanders, fish, crayfish, water-insects, water-snails, and aquatic bivalves. Holstein, Mecklenburg, Pomerania, Brandenburg, Silesia.

7. The **Otter** (*Lutra vulgaris*). Body flattened; legs short, with webbed toes; snout rounded; ears short, and can be closed by a fold of skin; tail flat, and pointed at its tip. Length of the body, twenty-eight to thirty-two inches; of the tail, fourteen to sixteen inches. Skin smooth-haired, shining dark brown above and below. Found on the banks of lakes, pools, ponds, rivers, brooks, etc., where fish is plentiful. It catches water-rats, ducks and geese, as well as their young, wild water-birds, frogs, fish, crayfish, water-insects. Especially destructive to fish.

8. The **Badger** (*Meles taxus*). Body heavy; legs short, plantigrade; toes with strong digging claws; snout pointed; canines not very large; both they and the carnassials much worn in old animals. Tuberculated molars well developed. The dentition and whole structure of the body show that the badger is not exclusively a flesh-eater. Length of body, three feet; weight, 22 to 33 lbs. Fur tolerably long-haired, yellowish whitey grey, mixed with black. Head with longitudinal stripes of black and white; tail short, yellowish grey.

The burrow is very large; several passages, the openings of which may be ninety-seven feet apart, lead

to the exterior. The badger only leaves its dwelling in the evening. It eats mice, birds which nest on the ground, especially their eggs and young, snakes, frogs, cockchafer grubs, earthworms, insects; also turnips, carrots, acorns, and sweet fruits. Although it is both harmful and useful, the latter is more generally the case. Its digging habits, however, are sometimes destructive, since it throws up young trees and other plants by the roots. The badger often sleeps several days in succession during the winter, although it does not hibernate. Its fat is used up during the winter.

Order: **Insectivora** (Insect-eating Mammals).

Since the Insectivora feed upon very small animals (insects, worms, snails), they cannot themselves be large. Only those species (hedgehog) which feed on small mammals and birds or upon vegetable matter, in addition to insects, are of medium size. The native species all live on or in the ground. The snout is extremely slender, and does duty as an organ of touch. The eyes are usually very badly developed. Incisors sharp; and the back teeth, which are completely coated with enamel, are remarkable for their pointed crowns. When the mouth is closed the upper teeth fit into the spaces between the lower teeth, and *vice versâ*. Consequently the shutting of the mouth forces the points of all the back teeth into any insect which happens to be between the jaws. The Insectivora are plantigrade (p. 22). Here belong the following forms: the Shrews (*Sorex*), the Mole (*Talpa europæa*) and the Hedgehog (*Erinaceus europæus*).

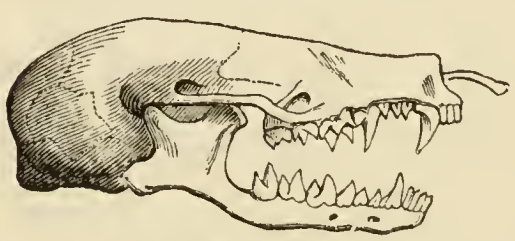

Fig. 16.—Skull of the Mole.

The **Shrews** (*Sorex*) are small animals with a

superficial resemblance to mice, with slender soft-haired bodies, small eyes, and tolerably long, thickly haired tails. Shrews are extremely voracious, eating daily more than their own weight of food, and destroying an enormous quantity of subterranean vermin. They live in underground passages, not usually made by themselves, but dug out by field-voles. They smell strongly of musk, secreted by two glands in the hinder part of the body.

The blackish-brown Shrew-mouse, or **Common Shrew** (*Sorex vulgaris*), and the **Lesser Shrew** (*Sorex pygmæus*), only about two inches long, kill, in the corn-fields, gardens, or woodland, an enormous quantity of noxious insects found in the earth, together with

Fig. 17.—The Common Shrew (*Sorex vulgaris*).

their larvæ; also snails and worms, and sometimes field-voles, and are in the highest degree serviceable. But the larger (up to $3\frac{1}{2}$ inches long), black **Water Shrew** (*Sorex fodiens*), although serviceable on land in the same way as the other kinds, is very injurious to fishing and fish-breeding, since it devours the small fish and kills the larger ones, eating out their eyes and brains.

The **Mole** (*Talpa europæa*). Body thick, cylindrical. Legs short, fore legs broad and spade-like, with broad digging claws. Eyes small, scarcely visible among the fur. No external ears; the auditory opening can be completely closed by a fold of skin. Shining black fur. The mole is found in every soil

inhabited by insects and earthworms, provided it is not too stiff, but yet sufficiently coherent to dig passages in, which will not at once collapse. Its presence is known by the heaps which it throws up. The nest, however, is always found under a larger heap, frequently hidden under tree roots, walls, etc., though sometimes in the open field. It consists in the first place of a nearly round dwelling-chamber, softly upholstered with vegetable substances; this is surrounded by a labyrinth of passages. From the nest a passage runs to the mole's hunting-ground. The walls of this passage of the labyrinth, and of the nest, are hard. The wider and subterranean channels, which the mole digs out when it is simply catching insects in the soil, easily fall in again, and the animal takes no pains to compact their walls. The highway to the hunting-ground, in which the animal can progress very rapidly, can be at once detected, not like the ordinary passages by a small chain of mole-hills composed of the thrown-up earth, but by a depression, since in its preparation the earth is laterally compressed and not thrown out. This tube is shorter or longer according as the hunting-ground is in the immediate neighbourhood or further off; it may be 100 or 160 feet long. The mole sleeps in the nest during the time not employed in seeking for food, and goes three times a day on the hunt for insects (early morning, midday, and before sunset in the evening). Having reached the subterranean hunting-ground, it tracks to some distance the insect larvæ, and worms found in the soil, being aided in this by its long snout. It daily devours more than its own weight. During summer the mole digs its passages near the surface, since larvæ and worms are then found in the uppermost layer of earth. In winter, when these withdraw into the depths of the soil, it digs much deeper channels. It does not fall into a winter-sleep. The young (three to seven) are born in

May, June, or July. The mole never gnaws plants. It does service, sometimes very great, by eating many wireworms, grubs, snail embryos, earth caterpillars, mole-crickets, and other earth-inhabiting insects, as well as their larvæ. It also willingly eats earthworms, but whether this does good is not definitely known. But under certain conditions it may also do harm, rooting up plants as it makes its heaps. Grass and grain suffer little, if at all, by this; other plants more; while young flax-plants perish if their roots are loosened. Mole-hills in hayfields and cornfields are a nuisance at harvest time. Moles are not to be endured in the neighbourhood of dams, since their borings may become the immediate cause of flooding. Trapping may usefully be resorted to in cases where moles are harmful.

The **Hedgehog**, or **Hedgepig** (*Erinaceus europæus*). When danger threatens it rolls itself into a ball covered all over with prickles, and is in this way secured from the attacks of most enemies. The hedgehog goes on the hunt in the evening; while during the day it sleeps in its hiding-place, situated in such places as the side of a ditch, hedges, or under heaps of brushwood. It preys more particularly on field-voles, sometimes also on eggs and small birds (chickens occasionally), lizards, grass-snakes, adders (by the bites of which it is unaffected), frogs, cockchafers and their larvæ, field-snails, earthworms, and similar small deer; now and then on fallen fruit and juicy plant-roots.

Order: **Cheiroptera** (Bats).

All Bats, except a few tropical genera, feed on insects, and possess teeth like those of the preceding order of Mammals (p. 30). The leading feature is the characteristic modification of the fore limbs into a flying apparatus. The bones of the forearm (Fig. 18,

u, *r*), the metacarpels (*mc*), and the phalanges (except in the case of the thumb, which possesses a sharp claw (*p*)) are of great length; and between the long fingers, between the fore and hind limbs, and, last of all,

Fig. 18.—Skeleton of a Bat.

between the two hind limbs there is an elastic membrane, serving both for flight and touch. Sight ill developed, since the bat is a nocturnal animal; a

delicate sense of touch has its seat not only in the flying-membrane, but also in the skin of the ears, which are often very large, and in the membranous flaps which, in a few genera (the "leaf-nosed" bats), occur on the nose and lips. As is well known, bats sleep in the day; and they also hibernate in chimneys, hollow trees, ruins, and other similar places of concealment.

They principally devour night-flying moths, and spiders; and, since they use a great quantity of nourishment, are of great service, since the caterpillars of many of the species they destroy are very injurious to agriculture or forestry. About nine species live in Britain, but there is no use in enumerating them here.

Order: **Rodentia** (Gnawing Mammals).

Two long incisors (Fig. 19), the crowns of which are continually being worn down, while a corresponding growth takes place at the root-end. These incisors are used for gnawing, in which process the lower jaw

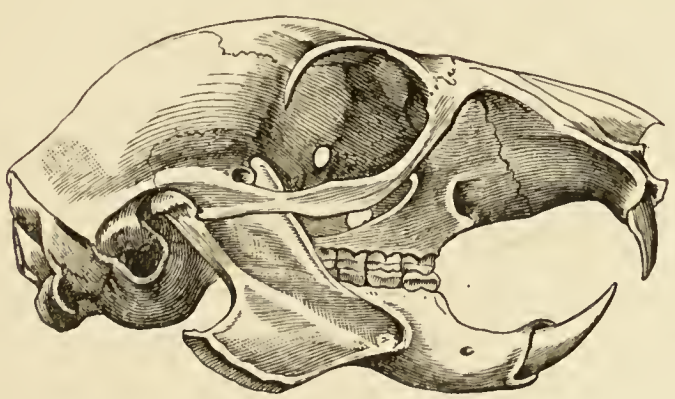

Fig. 19.—Skull of Squirrel.

is rapidly moved backwards and forwards. Gnawing wears down these teeth less in front than behind, owing to the presence of a thick layer of enamel in the former position. Their crowns, therefore, maintain a chisel-edge. That the incisors never stop growing

is clearly seen when the usual wearing down does not take place, as, *e.g.*, when the lower jaw is placed obliquely under the upper jaw, or when a tooth is absent in one jaw, under which circumstances the corresponding incisor in the other jaw is not worn down. In such a case the incisors continue to grow, ultimately curving upwards or downwards, and becoming tusk-like structures (Fig. 20). The Rodents have no canines. In those Rodents which feed both on animal and vegetable food (the "Omnivora," *e.g.* squirrel, common mouse, brown rat, etc.), the crowns of the back teeth are completely covered with enamel; in the purely vegetable feeders ("Herbivora," *e.g.* hare, rabbit), they are compound teeth (p. 22). In most Rodents the hind feet are longer than the fore, giving a springing gait. Eyes large. Many forms have "cheek-pouches," in which the food they obtain can be stored up for some time. When the pouches are full, a muscle contracts by which their ends are drawn backwards; they are emptied by the animal pressing them with its fore feet. The majority of Rodents are small, they are at most of medium size (hare). The majority of the species have great powers of reproduction, by which the injurious kinds are sometimes rendered a very great pest. The British forms injurious to agriculture principally belong to the families of hares, mice, and voles. The squirrel (*Sciurus vulgaris*), and the dormice (especially *Myoxus avellanarius*) are solely of importance in forestry.

Family: **Leporidæ** (*Hares and Rabbits*).

Skull somewhat long. Two small incisors behind the two large upper ones. Ears long and spoon-shaped. Upper lip cleft. Back teeth with enamel folds. Here belong the hare (*Lepus timidus*) and rabbit (*Lepus cuniculus*).

Hare (*Lepus timidus*). Ears longer than the head. Eyes yellowish brown. Fur rusty yellow to grey on the upper side, white on the under side. The doe litters in an open "form;" the young are born

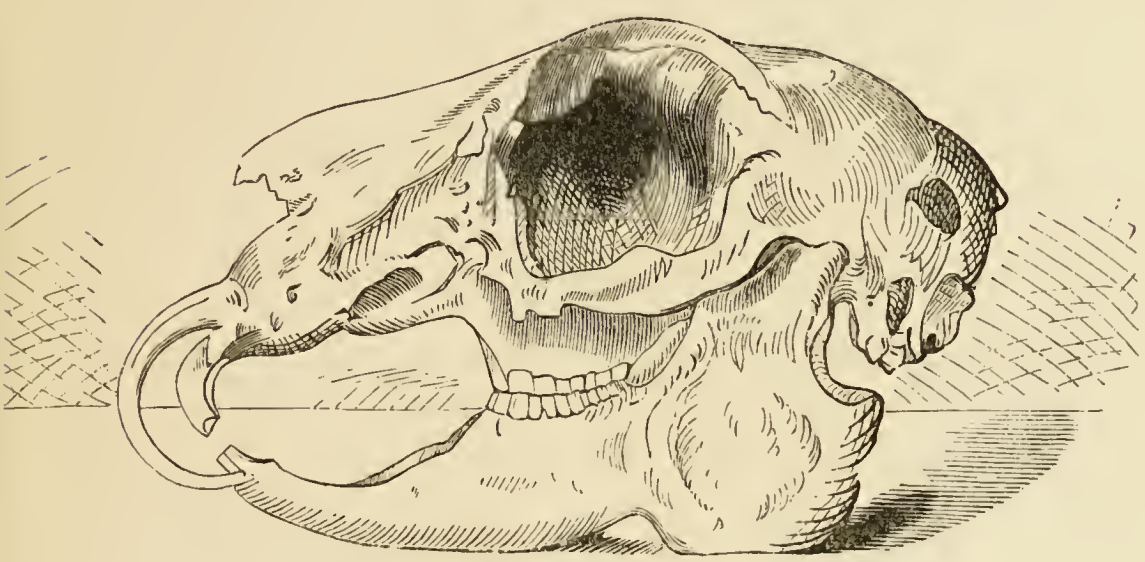

Fig. 20.—Abnormal Tooth in Hare.

covered with hair and with open eyes. Mature animals breed four or even five times a year, producing two to four leverets each time. The hare is injurious to agriculture, eating cabbages, rape, turnips, clover, vetches, young corn-plants, carrots, and grass. It also eats many weeds. It is, however, less injurious than the rabbit, for it does not burrow. The damage done by the hare is also less evident, since this restless, fastidious animal seldom feeds continuously in the same spot.

Rabbit (*Lepus cuniculus*). Ears shorter than the head. Eyes dark-brown. Fur yellowish brown to greyish yellow on the upper side, redder in front. Under fur bluish grey. Shape more compressed. The rabbit breeds more rapidly than the hare. Five to six times yearly the doe brings forth four to eight young, which, after six months, can again reproduce. Dwelling subterranean. Young, blind and hairless at birth. As the rabbit burrows, it is limited to certain districts, for the soil must not be too stiff and firm,

nor, on the other hand, too light and incoherent. The rabbit is injurious in the same way as the hare, but the damage is more obvious (see above); and as a result of its burrowing habits it does infinitely more damage. Both in sand-hills and in alluvial sandy soil rabbit-burrows lead to the blowing away of material only held together by sand-plants. Kept down by shooting, netting, and ferreting (p. 27).

Family : **Muridæ** (*Mouse Family*).

The mouse-like animals (the larger species of the family are called "rats") closely resemble the representatives of the following family, but are distinguished from these (the "voles") by their slender body, longer legs, a more pointed head with longer

Fig. 21.—The Hamster (*Cricetus frumentarius*).

always clearly visible ears, and usually, with the exception of the hamster, by a tail equal in length to the body. The hind legs are longer than the fore legs, hence the hopping mode of progression. Three back teeth on each side of each jaw, possessing a tuberculated crown completely covered with enamel.

The Hamster (*Cricetus frumentarius*).—The Hamster has cheek-pouches, and a very short, thick, but short-haired tail. It attains the size of the brown rat. Bright yellowish brown; belly and legs black. The hamster is found almost exclusively on fertile soil devoted to cultivation. It appears locally, and then for several years in great abundance, so that it is often caught in tens or even hundreds of thousands. Favourite food: wheat, field-beans, and peas, then rye and similar grain; and, last, roots, turnips, young corn-plants. Sometimes, too, the hamster eats animal food—worms, insects, lizards, small birds, eggs, and mice. As a winter store it usually only accumulates grain, beans, and peas in its hiding-place, often to the amount of more than five gallons. A little heap of thrown-out soil marks on the surface the position of its nest. The entry to this runs vertically down into the soil. Six to twelve young, twice a year. The dwellings of the hamster, which are situated in stubble-fields, can easily be found; and by digging them up, particularly in spring and late summer, when there are young ones, the number of these destructive Rodents can be greatly reduced. May be caught in traps.

Genus Mus (Mice and Rats) includes Rodents without cheek-pouches, and with long, scaly, ringed tails. Two large species ("rats") belong here, namely—

The common **Black Rat** (*M. rattus*), indigenous to Europe since pre-historic times, and the stronger, somewhat larger—

Brown Rat (*M. decumanus*), with greyish white belly (while the first-named species is black on the upper and only slightly brighter on the under side). The brown rat migrated during the first half of the eighteenth century from Asia into Russia, and about the same time from Further India to England by means of ships. Since then it has spread all over Europe and other parts of the world, and in many regions has quite driven out the black rat. Both kinds of rat eat almost everything, and are a pest in housekeeping, as well as in agriculture. They feed on insects, mice, eggs, and chickens, will even bite pieces from the living bodies of grown poultry and fattening swine, and also devour young geese and ducks. They eat grain, peas, beans, potatoes, carrots, turnips; bread, cheese, and similar provisions. Multiply very rapidly. Can be driven away by clacking-mills, and to a great extent by noise. Caught in traps.

Besides these, four mice belong here:—

The **Common Mouse** (*Mus musculus*). Back yellowish grey-black, gradually shading into a somewhat lighter tint on the under side.

The **Wood Mouse**, or **Long-tailed Field Mouse** (*M. sylvaticus*). Back a brown shade of yellowish grey; belly white, sharply marked off; relatively very long hind legs, hence a hopping gait. The long-tailed

FIG. 22.—The Long-tailed Field Mouse (*Mus sylvaticus*).

field mouse penetrates tolerably far into woods, but is also found in plantations and gardens, sometimes also in quite treeless regions. On arable land it may adopt the habits of the field vole (p. 42), but as it does not multiply so rapidly is not nearly so injurious. It may also live either for a short time or permanently in houses, adopting the same habits as the common mouse.

The **Harvest Mouse** (*M. minutus*). Small, pretty; back yellowish brown red, belly of a sharply marked-off white. Lives in cornfields during the summer; in harvest time by the field-paths; during winter in barns and haystacks, but also in outdoor nests in the fields. Climbs among the grass and corn-haulms, and the small stems and branches of other plants, including shrubs, holding fast, not only by the feet, but also by the tail. Builds a beautiful spherical nest with a

side entrance out of the haulms and leaves of grass and corn, or out of other leaves. Devours seeds, especially grain, oats being the favourite.

The **Corn Mouse** (*M. agrarius*). Back brownish red with longitudinal black stripes. In plains east of the Rhine. Usually local, but then very abundant.

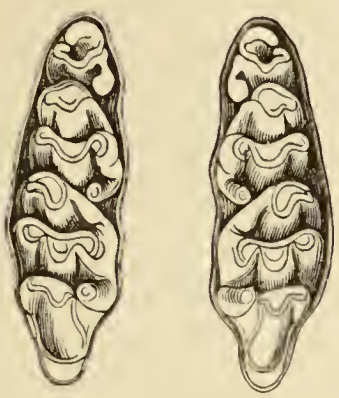

FIG. 23.—Upper Back Teeth of Brown Rat, seen from grinding surface.

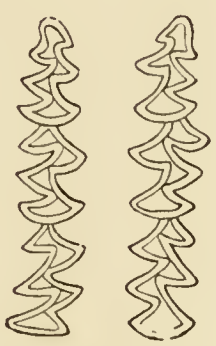

FIG. 24.—Upper Back Teeth of Water Vole, seen from grinding surface.

Chiefly in cornfields and fruitfields; digs holes in the soil. In autumn it often occurs in the field in large colonies. Food: grain, beans, peas, potatoes, turnips, carrots. In winter in the barns and dwelling-houses of farmers.

Regarding the means of destroying those mice which are sometimes damaging to agriculture (*M. sylvaticus* and *M. minutus*), see methods mentioned under "Field-vole" (p. 43).

Family: **Arvicolidæ** (*Vole Family*).

The large voles are also popularly called "rats," the smaller ones "mice." They closely resemble the true mice and rats (p. 38), but are distinguished from them by their plumper, more compressed body; a a thicker head with blunt snout, and ears quite hidden in the fur; and a short, tolerably hairy tail, on which no rings of scales can be distinguished. There are on each side of each jaw three back teeth, of which each appears to consist of two rows of three-sided prisms,

fused together along the middle line (cp. Figs. 24 and 23). The native species all belong to the genus *Arvicola*; the Bank Vole (*Arvicola glareolus*), the Water Rat, or Water Vole (*A. amphibius*), and the Short-tailed Field Mouse, or Field Vole (*A. agrestis*).

The brownish-red **Bank Vole** (*A. glareolus*) occurs in forests.

The **Water Rat**, or **Water Vole** (*A. amphibius*). Body six inches long, tail half the length of the body. Fur of one colour, brighter on the under side, varying from brownish grey to brownish black on the back, and from whitish to greyish black on the belly. On the banks of rivers, brooks, ditches, canals, etc.; also on damp low-lying meadows and fields. Digs much-branched passages in the soil; this often takes place in embankments to such an extent that it finally leads to their complete destruction. The vole also does damage in grass-fields and cornfields in the same way as the mole (p. 33). In its case, however, there is no compensating service. It certainly eats insects and worms, but its chief food is of vegetable nature; grain, potatoes, turnips, and carrots are devoured by it in large quantity, and in particular stored up in its hiding-place. It also destroys the roots of grass and corn, and eagerly devours chickens and the eggs of ducks and geese. A variety (*A. amphibius*, var. *terrestris*) occurs in dry soils, and is distinguished by its smaller size, lighter colour, and shorter tail. Its habits are the same as those of the ordinary form, but it is more given to attacking trees.

Traps, shooting, poisoning with celery stumps hollowed out and filled with phosphorus, or else with phosphorus paste.

The **Field Vole**, or **Short-tailed Field Mouse** (*A. agrestis*). A small animal, with dark brownish grey back and greyish white belly. [Lives in pastures, especially those which are low-lying and damp. Large numbers are found together, and they make deep burrows in

the soil, each pair having a special nest to themselves. Three, four, or even more litters per year; four to ten young in each litter. Its favourite food consists of roots, young shoots of grass, etc., and the tender bark of shrubs, but nothing of vegetable nature comes amiss. Specially destructive in permanent pasture.]

Remedies. (*a*) *Preventive measures.* Protection of its natural enemies (weasel, stoat, polecat, fox, hedgehog, owls, buzzards, kestrels, the smaller sea-gulls). Catching in traps, etc., in the spring, when the voles are only present in small numbers.

(*b*) *Destructive measures*, which should be as generally used as possible in infested districts. If a field has been completely devastated, or the crop is over: (1) Working the soil with a spiked roller; (2) Partial inundation of the lower-lying fields. If it is desired to kill the voles and spare the crop as well, the following means may be recommended: (1) The digging of cylindrical holes six inches across and two feet deep, especially at the margins of the fields and in the furrows, as well as—at harvest time—on any foot-paths that may be found. The voles fall into these holes, cannot get out again, and are starved. (2) The employment of poisons. (Care must be taken that no children or domestic animals are poisoned.) Phosphorus paste is best.

Fig. 25.—The Southern Field Vole (*Arvicola arvalis*).

The **Southern Field Vole** (*A. arvalis*) plays the same destructive part on the Continent that the preceding form does here (Fig. 25). *Remedies* —see above.

ORDER: **Ruminantia** (CUD-CHEWING MAMMALS).

The feet end in two hoof-covered toes, besides which two "after toes" are present. The upper incisors are absent, with few exceptions, but many deer have canines in the upper jaw. The back teeth of Ruminants are compound teeth. The lower jaw is smaller than the upper, and during chewing undergoes lateral movements, so that the plants taken in as food are ground up, as it were, into small pieces, between the projecting enamel ridges of the upper and lower back teeth. The stomach consists of four subdivisions; these are (1) the rumen, or paunch, where the greater

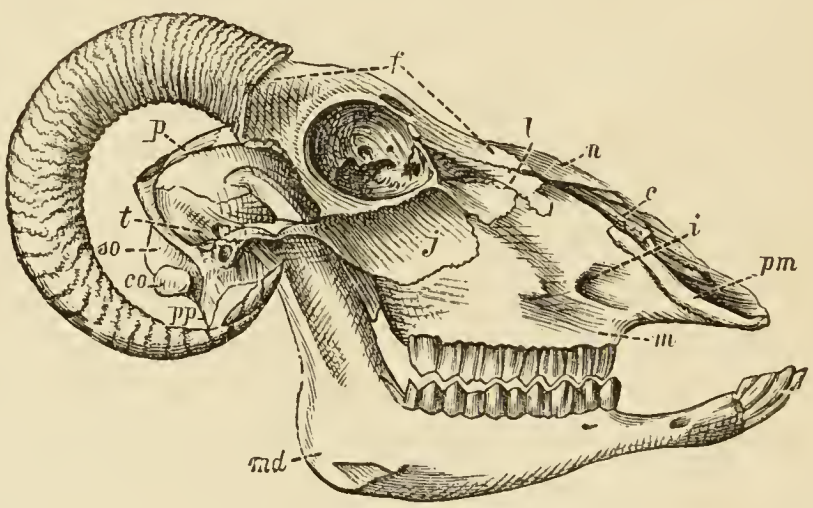

FIG. 26.—Skull of a Sheep.

part of the food and water taken collects; (2) the reticulum, or honey-comb stomach; (3) the psalterium, or manyplies; (4) the abomasum, reed, or rennet stomach. The last is the second largest part, and in it the same chemical changes take place as in the simple stomach of a non-ruminant. After the food has remained for some time in the paunch it passes up again through the gullet, and [as the "cud"] undergoes a second chewing. The soft mass resulting is once more swallowed, and passes into the psalterium and abomasum.

Not only the families of *Tylopoda* (Camels, Llamas),

and *Camelopardalidæ* (Giraffes), but also the large family of *Cavicornia*, to which, amongst others, the ox, sheep, and goat belong, will be passed over in this book. I need only mention the—

Family: **Cervidæ** (*Deer Family*).

Deer have branched horns, known as antlers. With the solitary exception of the reindeer, they are only found in the males. They are bony structures borne upon projecting knobs (horn cores) of the

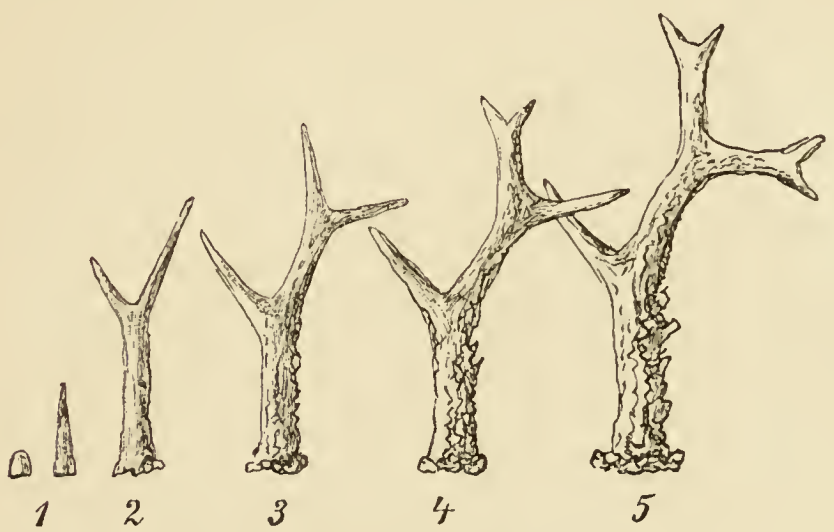

Fig. 27.—Development of Roebuck Antlers.

frontal lines. After each rutting-season the antlers are cast, new ones, clothed at first with a soft skin [the "velvet"], are developed. Before the next rutting-season the dermal part of the skin unites firmly with the underlying antler, and becomes itself ossified, while the epidermis shrivels up, partly peels off in bits, and is partly rubbed off by the animal against tree trunks. If the conditions of life (food, weather) are favourable, the animal acquires a new side branch to each antler every year, at any rate, so long as he continues to get bigger and stronger. The one-year-old male ("brocket") has therefore a simple unbranched antler, the two-year-old ("spayad")

one side branch as well, the three-year-old ("sorel") three points in all; the four-year-old ("staggard") has four points; the five-year-old ("stag") five, and so on.

In Britain two indigenous deer are found—the Red Deer (*Cervus elaphus*) and the Roebuck (*C. capreolus*); a third species, the Fallow Deer (*C. dama*), lives in South Europe and Asia Minor [and the exact date of its introduction into Britain is not known].

The **Red Deer** (*Cervus elaphus*). Six to seven feet long, and four feet high. Antlers rough and cylindrical for their entire length; each in its normal condition has two front branches ["brow" and "bez-tyne"], a middle branch ["tres"], and a "crown." Tail small. Body of a brownish colour, becoming red in summer. A light yellowish brown spot on the tail. Male larger than the female, with long dark hairs on the neck during the breeding-season (autumn). The young ("calves") are spotted with white till their first change of coat in October. The hind brings forth one or rarely two calves in May or the beginning of June. The stag sheds his antlers at the end of February; the new ones are already full grown in July. So long as they are growing the stag keeps to the low woods, and first seeks the high-lying forests when they are completed. He only leaves the forest for any length of time during the breeding-season, but, wherever possible, comes to the field for a short time every evening to feed on cabbages, peas, beans, young corn, clover, lupines, grass, etc. Turnips, carrots, and potatoes, dug out of the ground by the fore legs, are also devoured. In this way red deer do a great deal of damage, not only directly in feeding, but also, to a larger extent, by trampling down the crops. In autumn and winter they chiefly feed on acorns, beech-nuts, buds and young shoots of various trees. They also peel the bark from young trees, and often cause damage while rubbing the remains of the velvet from

their antlers. Red deer are injurious to agriculture and forestry. Suitable fencing of fields, gardens, etc., to be protected.

The **Roebuck** (*Cervus capreolus*) measures up to three and a half feet long, and about two feet high. Antlers (Fig. 27) only slightly branched, and rough all over; beams and branches cylindrical. No brow-tynes, and usually only three branches. Tail extremely small and inconspicuous. Legs long and slender. Summer coat greyish brown, passing over to a reddish tint; the longer winter coat brownish grey. A whitish patch on the rump. The young ("fawns") have at first white spots on a brownish ground.

Breeding season in August. The female ("doe") brings forth her two fawns in May or June. The roebuck keeps principally to the lower and middle forests, especially in places where glades, rich in grass and herbage, and cornfields or meadows alternate with woodland. In the evening it comes out of the cover to eat in the fields and meadows; towards morning it withdraws again. The roebuck devours both young corn and corn in the ear; also ears of millet, beans, peas, clover, and lupines. It does not appear to touch potatoes and turnips. The bucks in particular do much mischief by trampling about in cornfields.

The **Fallow Deer** (*Cervus dama*) is about four feet long and three feet high; antlers rough and cylindrical only towards the root, with tolerably smooth, flat, shovel-like ends. Old individuals are pale brown, the summer coat is reddish and brightly spotted; belly whitish; a white patch on the tail. The young have sharply marked bright spots. In its habits this non-indigenous species agrees in many respects with the red deer, but changes its abode less. Towards evening it eagerly leaves the forest in order to seek its food in the cornfields. As the fallow deer lives in large herds its trampling does much damage.

Order: **Multungula** or **Pachydermata** (Many-hooved or Thick-skinned Mammals).

Non-ruminating hoofed animals with thick, often callous, naked, or scantily haired, frequently bristly skin and with three to five toes, which, though they are not all developed to the same extent, are yet never rudimentary. The various species are very unlike one another as to food and dentition. Here belong domesticated swine, and a single species—formerly occurring wild in Britain—

The **Wild Boar** (*Sus scrofa*). On each foot four toes, of which the two hinder are small and do not usually touch the ground. The wild boar agrees in the general conformation of its body with the common domesticated swine. Six incisors in upper and lower jaw; the lower ones forwardly directed. The canines, which are more developed in boars than sows, curve outwards and upwards in both jaws as "tusks." On each side of each jaw seven tuberculated back teeth completely covered with enamel. Length of the body 5 feet 10 inches; length of tail 1 foot 8 inches. Colour: black and rusty brown. The young ones are white, spotted and striped with dark brown. The wild boar likes damp, swampy, but at the same time thickly overgrown districts, where it remains hidden in the day, only seeking the fields and meadows when it has become dark and quite still. It then chiefly feeds on turnips, carrots, and potatoes, rooting them out of the ground; it also devours leguminous crops and grain, but treads down far more of these plants than it eats. Besides this, it also feeds on acorns, beech-nuts, hazel-nuts, and truffles. The wild boar does some service by devouring snails, worms, insect larvæ living in the soil, and also the pupæ of destructive species of caterpillars, which occur in the same situation; also voles. Thick hedges, in order to protect the corn from injury.

Order: **Solidungula** (Single-hooved Mammals),

to which the horse and the ass belong, need not be dealt with here; still less the other orders enumerated on p. 23.

CLASS II.: **AVES** (BIRDS).

Warm-blooded Vertebrates, which breathe by lungs, are covered with feathers, have no teeth but a horny beak, and lay hard-shelled eggs, which are hatched by the warmth of their body. They are adapted for movement in the air, though not all to the same degree. The fore limbs are modified into wings, in which, however, the parts found in Mammals can be recognized. We distinguish in the first place a small thumb, and then in most cases a two-jointed fore-finger and a small second finger. *Secondary quills* (Fig. 28, BB) are attached to the ulna, and *primary quills* (A, 1—10) to the two metacarpals and the finger joints, while the thumb bears the bastard wing (C). The tail feathers, or *rectrices*, are attached to the last joint of the tail. The body is clothed with stiff, tolerably long *contour feathers*, which conceal the soft short *down* from view. The bones are hollow and filled with air. Their cavities are connected with *air-sacs*, which are found in all parts of the body, and fill themselves with air from the lungs when the bird begins to fly. In this way its specific gravity is reduced. The body firm, especially the hinder part of it, which is almost immovable; the neck, which may consist of many vertebræ (even as many as twenty-two), can, on the contrary, be turned in many directions. Birds walk entirely on their toes; the metatarsals are fused with one of the rows of tarsals into a "*tarsus*" bone. Tarsus and toes are covered with horny scales.

A bird's egg (Fig. 29) consists of a germinal disc (*h*) from which the young bird develops, and which rests on the yolk, made up of substances serving for the nutriment of the developing bird: the yellow (*a*) and the white (*b*) yolk, as well as the albumen (*c*, c^1, "white of egg") in which lie two twisted cords

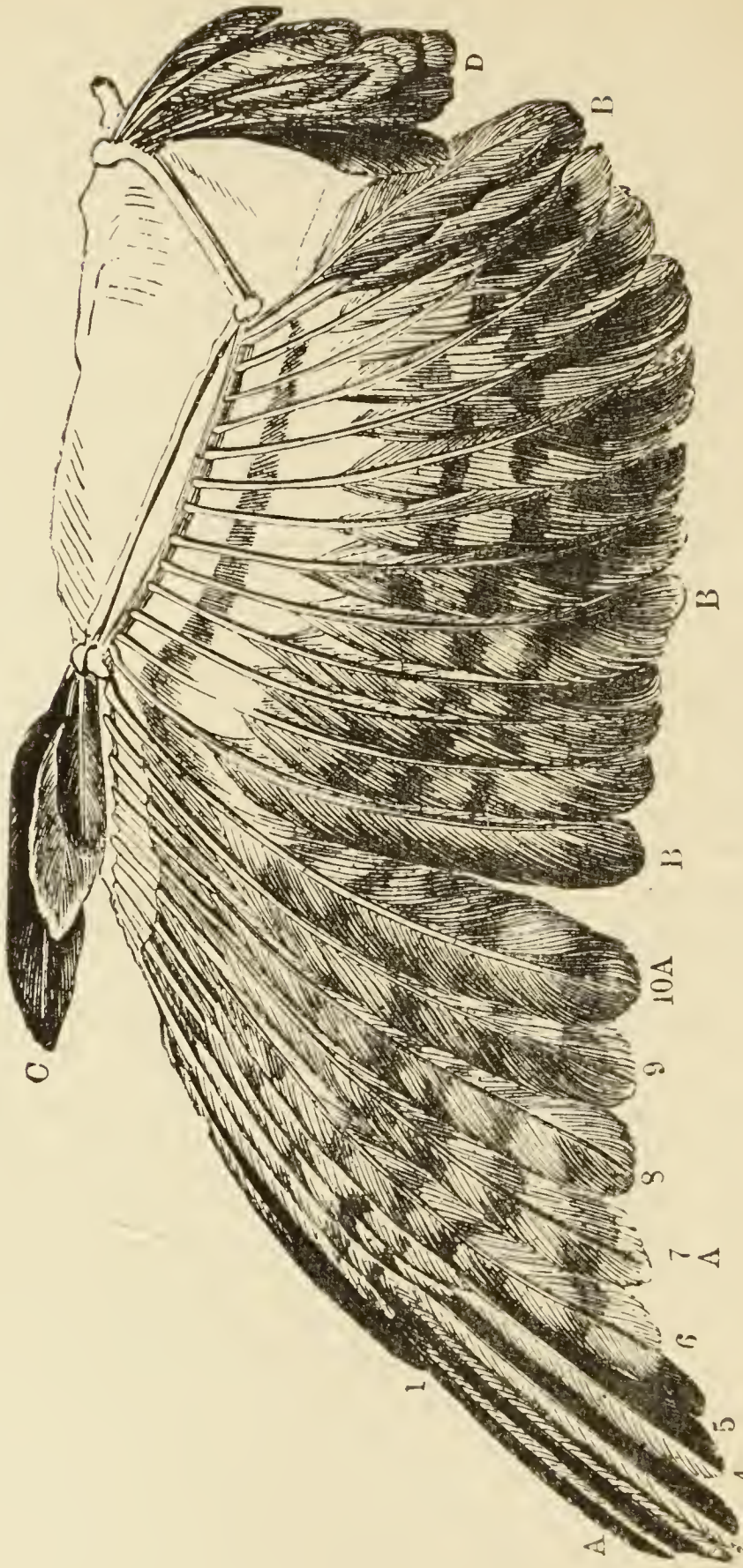

Fig. 28.—Wing of the Buzzard.

(*chalazæ*),—finally of protective structures: the shell-membrane (*e*) and the calcareous shell (*f*); *g* is the air-chamber.

When the young escape from the egg, they are either able to at once look after themselves more or less, at least to look for their food,—in which case they can see and are clothed with feathers at hatching (*precocious young; e.g.* fowls, ducks, gulls, and pewits),—or the young remain some time in the nest, as they are, to begin with, both blind and naked, and in this case they are fed for some time by the parents (*nestlings; e.g.* birds of prey, sparrows, nightingales,

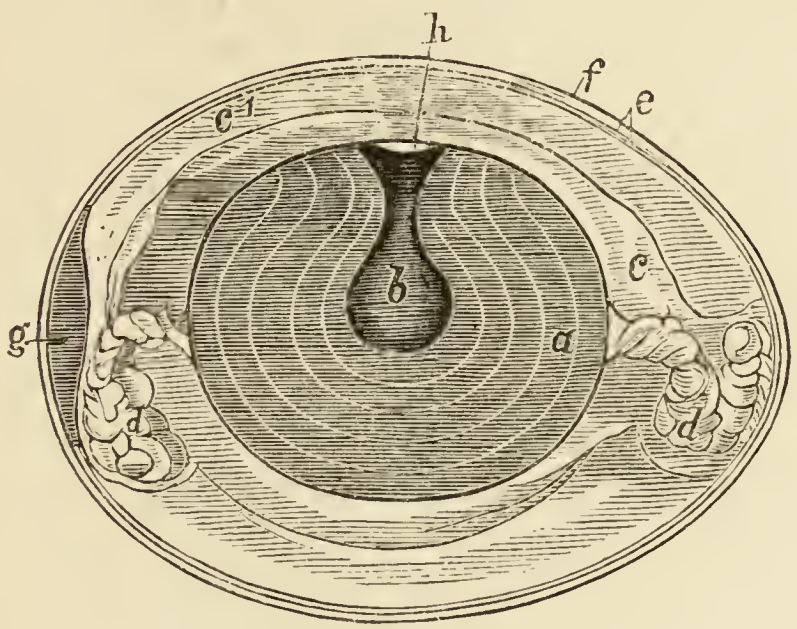

Fig. 29.—A Bird's Egg.

pigeons). In the frigid and temperate zones most species of birds do not remain in their native country after the breeding season; those which go south in the autumn are termed *migrants;* while birds which do not migrate, but remain in the district where they have bred, are known as *residents* (sparrow, jay, magpie). *Gipsy migrants* execute more or less extensive wanderings, influenced by want of food or other causes (woodpecker, titmouse, golden-crested wren, tree-creeper). The travels of such birds are not, like those of migrants, undertaken at a definite

time of year, or in definite directions (N., S.), but many of their species collect together in large flocks for the purpose of wandering, like migrants.

The following orders are usually distinguished:

FIG. 30.—The Eagle Owl (*Otus maximus*).

I. *Raptores* (Birds of Prey), II. *Scansores* (Climbers), III. *Passeres* (Singing Birds), IV. *Gyrantes* (Doves), V. *Rasores* (Scratchers), VI. *Grallatores* (Waders), VII. *Natatores* (Swimmers), VIII. *Cursores* (Running Birds).

The Order Cursores includes the ostrich-like birds, and will not here receive further notice.

ORDER: **Raptores** (BIRDS OF PREY).

Upper beak hooked, covered with a skin (*cere*) at its base; four toes possessing strong claws, and provided with pads in their under side (Fig. 31); wings powerful. Birds of prey live in pairs, and breed once a year in nests composed of pieces of wood and branches. The young are nestlings (p. 51). Sight keen. These birds feed almost exclusively on vertebrates, principally mammals and birds. An idea of their food can be gained by examination of their "pellets"—roundish balls composed of the indigestible parts of their food, and disgorged from twelve to twenty hours after feeding. Two groups are distinguished—*diurnal* and *nocturnal* birds of prey. The first (Figs. 31, 32) have a laterally flattened head, eyes directed laterally, and tolerably stiff feathers. The nocturnal forms ("owls," Figs. 30, 33) have a large head, flattened in front, with large eyes facing to the front, soft plumage, and hair-like feathers on the toes, of which two are directed forwards, one backwards, and one outwards. The radiating feathers round the eye constitute a "veil."

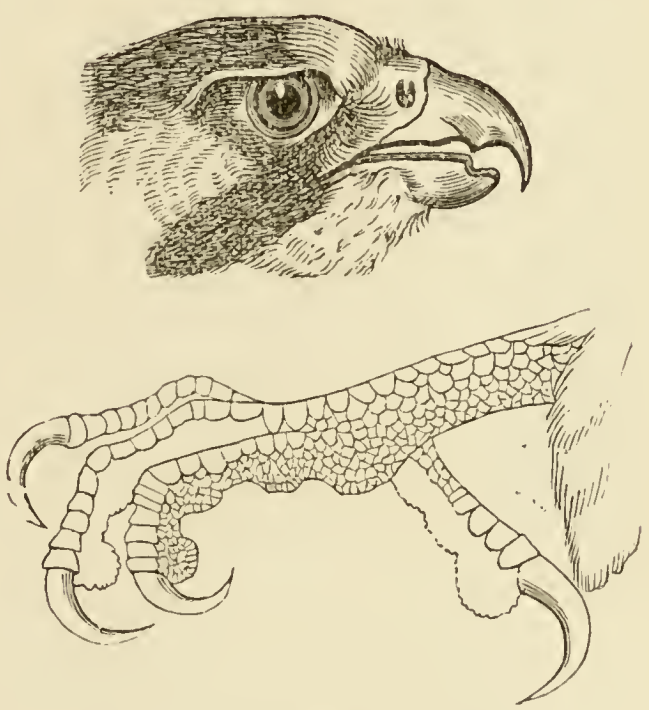

FIG. 31.—Head and Foot of Falcon.

Predominatingly harmful (from killing domestic mammals) are the following species occurring in Britain: the **Sea Eagle** (*Haliaëtus albicilla*), the **Golden Eagle** (*Aquila chrysaëtus*), the **Peregrine Falcon** (*Falco peregrinus*), the **Merlin** (*F. æsalon*), the **Hobby**

(*F. subbuteo*), the **Sparrow Hawk** (*Accipiter nisus*), the **Kite** (*Milvus regalis*), the **Goshawk** (*Astur palumbarius*), the **Harriers** (*Circus cyaneus* and *C. cine-*

Fig. 32.—The Golden Eagle (*Aquila chrysaëtus*).

rarius), and the **Honey Buzzard** (*Pernis apivorus*). The last effects damage by catching honey-bees.

Useful in the main, being destroyers of field-voles, are the following: the **Kestrel** (*Falco tinnunculus*), the **Buzzard** (*Buteo vulgaris*), the **Barn Owl** (*Strix flammea*, Fig. 33), the **Brown Owl** (*S. aluco*), the **Little Owl** (*Athene noctua*), a casual, the **Short-eared** or **Woodcock Owl** (*Otus brachyotus*), the **Long-eared Owl** (*O.*

vulgaris), and the **Eagle Owl** (*Otus maximus*, Fig. 30), a rare visitor.

A bird of prey cannot simply be classed as harmful or useful; a species mainly injurious may sometimes destroy a field-vole or a destructive bird, while a useful species may sometimes attack domestic poultry. Game-preserving is destructive of almost all the indigenous diurnal birds of prey, and of the owls to a less extent.

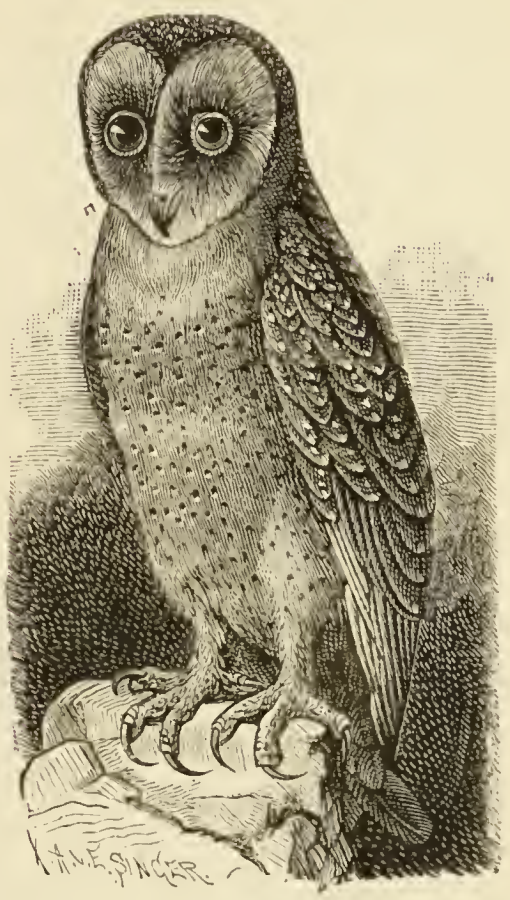

Fig. 33.—The Barn Owl (*Strix flammea*).

Order: **Scansores** (Climbers).

Birds with two toes directed forwards and two backwards. The young are nestlings. Here belong toucans, parrots, cuckoos, and woodpeckers. The first two groups are limited to the tropics; woodpeckers are only of importance in the culture of fruit-trees and in forestry. I describe briefly—

The **Cuckoo** (*Cuculus canorus*, Fig. 34). Fourteen inches long, tail eight inches. The yellowish beak is slightly curved; feet yellow. Back blue-grey in old birds, brownish in young ones. Belly white with dark transverse lines. Ten tail quills, flecked with white. Shy; flies like a bird of prey. The female lays her eggs at intervals of about fourteen days, and cannot therefore hatch them out herself. She lays the egg on the ground, and then takes it in her bill to the nest of a small bird which feed its young with insects (wagtail, grasshopper warbler, nightingale, robin, lesser white-throat, wren,

lark). The cuckoo's egg is generally hatched by the foster parent, and the true young often do not come out from the egg, owing to lack of warmth; or, if hatched, they are thrown out later on by the much

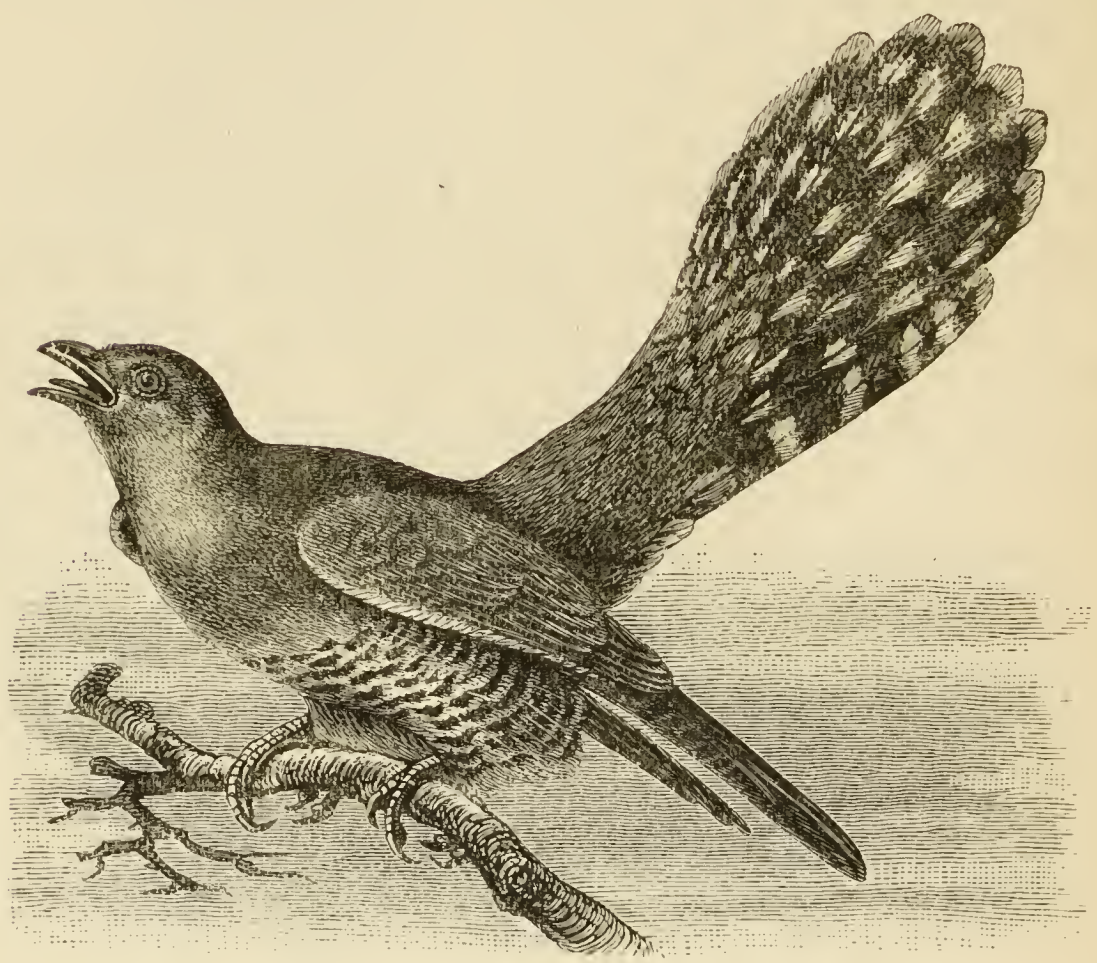

FIG. 34.—The Cuckoo (*Cuculus canorus*).

larger, rapidly developing young cuckoo. Every cuckoo, therefore, is so far harmful that it costs the lives of several insect-eating birds. But it far more than compensates for this by destroying insects. It is especially beneficial to fruit-tree culture and forestry, since it eats an enormous number of caterpillars; but in late summer it comes frequently from the woodland into the fields, and then eats the caterpillars of the cabbage white, cabbage moth, and silver Y moth, surface caterpillars, and the larvæ of the turnip saw-fly. It also devours mole-crickets and (naturally in the spring) cockchafers.

Order: **Passeres** (Perching Birds).

This order is essentially constituted by all those birds with helpless young (p. 51), which do not belong to the two preceding orders or the one next following. Beak without a cere. Three toes forwardly, one backwardly directed.

Group: **Hirundinidæ** (*Swallows*).

With short flat beak, broad at the base, with gape extending far back, and triangular as seen from above. In flight the beak is opened as widely as possible, serving for catching insects. Wings long and pointed. Feet short and weak, entirely unsuited or only poorly adapted for walking; their chief use is to enable the swallow to hold fast to different objects. Swallows fly quickly and catch insects while on the wing. The insects on which they prey are generally unimportant to agriculture and forestry; but they may also do good by catching crane flies (*Tipula*), and ribbon-footed corn flies (*Chlorops*), which often fly about our fields in enormous swarms in order to lay their eggs. All swallows are migratory birds. There belong here—

1. True **Swallows** (*Hirundo*), with forked tails; three toes directed to the front, one to the back. Here may be reckoned—**Swallow** (*H. rustica*), always broods in sheltered spots, *e.g.* inside a stable, summer-house, or verandah; **House Martin** (*H. urbica*), nests against buildings, under the eaves for example; the **Sand Martin** (*H. riparia*), breeds in the neighbourhood of streams, especially in vertical banks of loamy or coherent sandy soil, where it makes its nest at the end of a passage a yard long. The **House Martin** is shining black on the back, white on the entire under surface and rump. The **Bank Martin** is brownish grey on the back, white on the under side, with brownish-grey bands on the breast.

2. **Swifts** (*Cypselus*), with forked tails and four strong, curved, forwardly directed claws. Only one British species belongs here—the **Swift** (*Cypselus apus*), ten inches long, brownish black except for white throat, and with very long curved wings.

3. **Night-jars** (*Caprimulgus*), with tail not forked, soft plumage, large head and eyes; fly at night. One species belongs here—the **Goatsucker** (*Caprimulgus europæus*, Fig. 35), twelve inches long, grey on the upper side, spotted with blackish brown and rusty

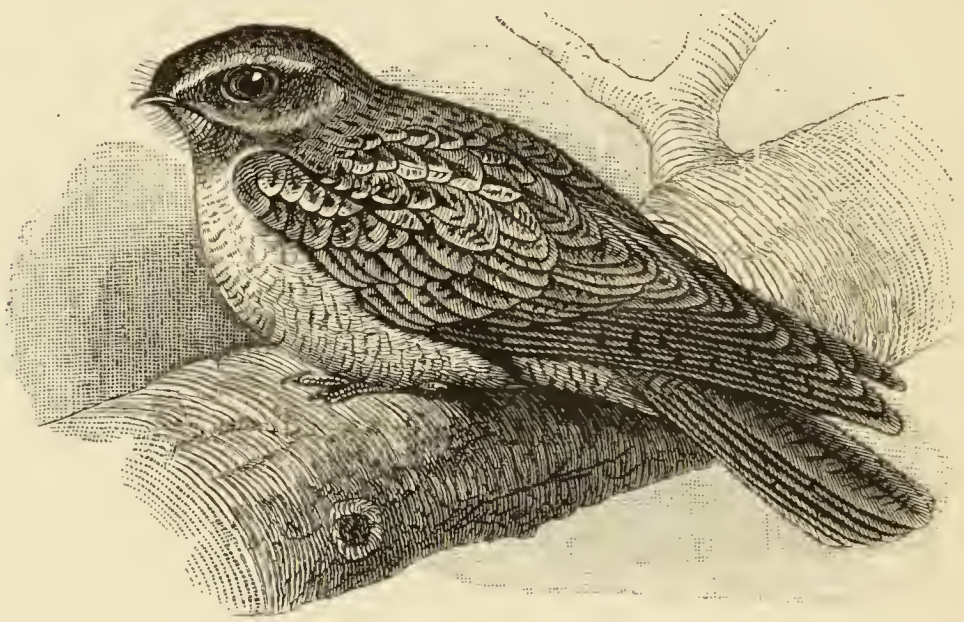

Fig. 35.—The Goatsucker (*Caprimulgus europæus*).

yellow, yellowish whitey-grey with dark wavy lines on the under side. In the day it flies awkwardly and heavily, and usually keeps under cover; by night it flies rapidly and boldly, especially in bare spots in woods, or in gardens and on fields. It haunts especially the neighbourhood of sheepfolds and cattle in the meadows, since it always finds flies and gnats there. It also catches cockchafers and various moths.

Group: **Magnirostres** (*Large-beaked Perching Birds*).

Beak strong, thick, often incurved near its apex. These birds eat almost all kinds of food, both animal

and vegetable. Here belong Starlings and Raven-like Birds (crows, magpies, jays).

The **Starling** (*Sturnus vulgaris*).

Plumage black, with a violet sheen. The tips of the contour feathers, however, are white or bright yellowish. These white patches become so well marked after the autumn moult, that they almost completely cover the shining metallic black of the feathers. They gradually become smaller; in the next spring they are almost or entirely lost. Very serviceable. Devours, especially in autumn, many field snails, also cockchafer grubs, wire-worms, grass caterpillars, grasshoppers, leaf-lice; also many insects destructive to fruit trees and forest trees. The starling, however, is able to do considerable damage to garden fruit trees, since it eats cherries, currants, and sometimes even pears. Starlings often settle on the backs of sheep and cows in order to pick off the vermin.

Genus: **Corvus** (*Crow-like Birds*).

Here belong—1. The **Jackdaw** (*C. monedula*), with relatively short beak and long tarsi. Black; side of the head and neck ashen grey. Breeds in holes in trees, chimneys, ruins, and towers. 2. The **Hooded Crow** (*C. cornix*); bright grey, except the head, throat, wings, and tail, which are black. Breeds in all parts of Europe east of the Elbe; occurs in Western Europe as a gipsy migrant in winter. 3. **Carrion Crow** (*C. corone*); black, beak stout and strongly bent at its end. Breeds in trees, but never (like the Rook) in large numbers together. 4. **Rook** (*C. frugilegus*); black, beak rather long; in adult specimens the head feathers are quite worn away at the base of the beak. 5. **Raven** (*C. corax*); much larger than the other species; black, beak very strong, strongly curved

along its entire upper side. Nowhere in large numbers.

Food, Benefit conferred, and Damage done. Ravens, and sometimes even rooks, attack lambs and sick sheep, also ducks, geese, fowls, and pigeons. Carrion crows and hooded crows rarely attack our domestic animals. All crows, however, steal the eggs of our poultry. They also injure sport, since they kill hares and rabbits, young fawns, quails, pheasants, etc. They do a little good, however, by devouring field-voles, but, as a rule, only catch the sick ones which are not able to move quickly. They do harm by

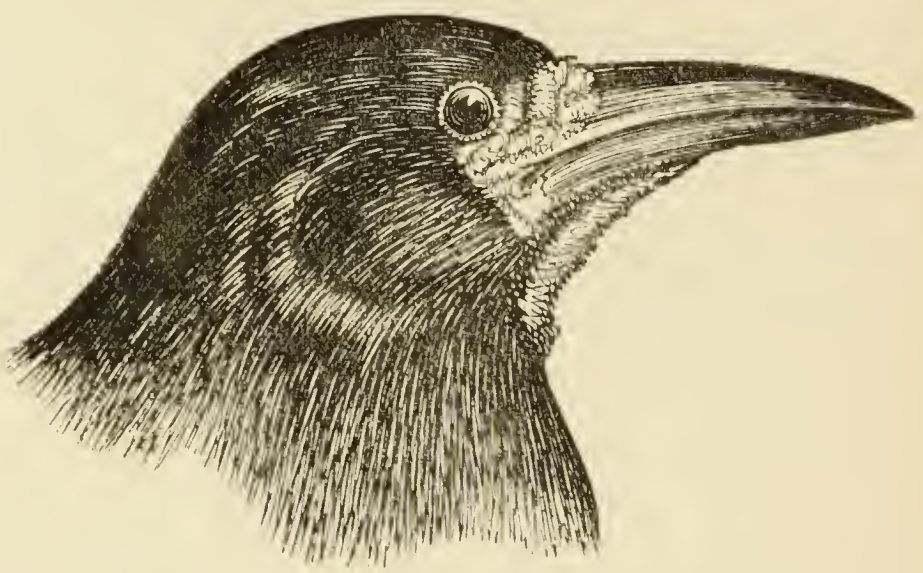

Fig. 36.—Head of Rook (*Corvus frugilegus*).

destroying useful insect-eating birds, also eating their eggs and young. But as insect-eaters, they are extremely useful; they devour cockchafers, wire-worms, butterflies, surface caterpillars, crane flies and their larvæ, and field snails; also many earthworms. As to the vegetable part of their food, they devour, in the first place, germinating seeds; grain, peas, beans. They also pick grain from the ear, both when ripe and, to a larger extent, when still soft; and in doing this pull down the ear so as to crack the stalk, thus causing more damage than by the mere eating. They also plunder the ripening peas, and feast upon

cherries, plums, apricots, and other juicy fruits; even potatoes and turnips. All crow-like birds do some harm and some good, only the raven (which eats scarcely any insects) is to be always reckoned as an enemy.

The **Magpie** (*Pica caudata*) and **Jay** (*Garrulus glandarius*) are resident birds closely related to the crows. The first affects open tracts of land (fields, meadows, gardens) in the neighbourhood of large trees; the latter is a woodland bird. Both birds eat almost everything: grain, acorns, beech-nuts, cherries, berries; cockchafers, wireworms, and similar insects; the eggs and young of useful insect-eating song-birds (such as titmice), also these little birds themselves, ducklings and chickens, young partridges, quails, pheasants, now and then field-voles. More harmful than useful.

Group: **Conirostres** (*Conical-beaked Perching Birds*).

Beak conical, thicker and shorter than in the species of the following group. They devour insects and seeds, a few species seeds exclusively. Here belong first the **Titmice** (*Parus*), gipsy migrants which are extremely serviceable both in fruit-tree culture and forestry. Then the **Larks** (especially the **Skylark**, *Alauda arvensis*, a resident), which nest on the ground, eating insects, seeds, and in winter even leaves; they feed their young, however, with insects. They do both good and harm, but the former mostly preponderates. In late summer and autumn, skylarks collect in flocks, and wander here and there for a long time: before this, they travel south; at this time many are caught and eaten. The male skylark sings beautifully, rising meanwhile high in the air. The **Buntings** (*Emberiza*) have a characteristic compressed and pointed beak; they seek their food on the ground in fields and meadows, and on roads. The food consists of grain and insects; but since these birds never

take grains from the ear, they only do damage by picking them up at seed-time. They feed their young with insects. The damage is usually very inconsiderable, but, on the other hand, the benefit conferred is slight. (**Yellow Hammer,** *E. citrinella,* a yellow-coloured resident. The **Common Bunting,** *E. miliaria,* a grey-coloured migrant, etc.) In the family of **Finches** a number of species are included which are of small agricultural importance: *e.g.* the **Bullfinch** (*Pyrrhula vulgaris*), specially attacks fruit-tree buds in March; the **Goldfinch** (*Carduelis elegans*); the **Siskin** (*Chrysomitris spinus*); the **Lesser Redpoll** (*Linota linaria*); the **Greenfinch** (*Ligurinus chloris*). A few species, however, must be dealt with more fully, and, first,—

FIG. 37.—Head of Bullfinch.

The two **Sparrows,**

i.e. the **House Sparrow** (*Passer domestica*) and the **Tree Sparrow** (*P. montana*).

House Sparrow: ear region bright grey. A rust-coloured or yellowish streak behind the eye. The whole throat black in the male. Wings with a yellowish-white transverse band. **Tree Sparrow**: ear region black. A black streak behind the eye, a white band round the neck, and a black patch on the throat. Wings with two white transverse bands. The two sparrows are very much alike in their habits, but the house sparrow frequents more the neighbourhood of human dwellings, even in large towns. Both sparrows are mainly harmful; where seeds (especially those containing starch, *e.g.* corn) are available, they prefer this kind of food to any other; and, besides this, they chiefly bring up their young on soft unripe grain. Sparrows devour the germinating corn after seed-time, and also pick the

grain from the ear, in which process they at the same time do damage by breaking down the haulms so that the grain falls out. They pick the young peas from their pods; devour, too, several juicy tree fruits, *e.g.* cherries and grapes; and destroy young garden seedlings, *e.g.* lettuce, spinach, garden flowers. The house sparrow eats more insects than the tree sparrow (among them—geometer caterpillars, injurious roller caterpillars), but leaves the most noxious kinds untouched. Both sparrows are residents, but in autumn and winter often collect together in large flocks.

The **Linnet** (*Linota cannabina*),

with grey-brown darkly spotted back. Belly whitish, tail black with broad white margins. During summer the top of the head and the breast of the male are of a beautiful red. They are often found together in flocks during September. In spring and summer they chiefly live on oil-containing seeds, and may even do some good by eating the seeds of charlock; usually, however, doing much more harm by devouring the seed of rape, flax, linseed, and hemp.

The **Chaffinch** (*Fringilla cœlebs*).

A white patch on the two outermost tail feathers and the ones next them. Wings with one white and one yellowish transverse band. Male: upper side of head and neck bluish grey, back brown, breast reddish brown. Female: back grey-brown, belly whitish, breast ash-grey. The chaffinch inhabits forests, both those of ordinary foliage trees and those consisting of conifers; it also nests in gardens and plantations. At the beginning of September the males separate from the females, and both sexes collect in large flocks which haunt gardens, avenues, and bushes. In mild winters they remain resident, but travel away if the cold is greater. The chaffinch devours oil-containing seeds by preference, but also eats starchy ones, and seeks its

food on the ground. It does a great deal of damage in cornfields by picking the seeds out of the soil after they have been sown; but does not take the grain from the ear. It also eats young seedlings. But valuable services more than counterbalance the harm done. When the chaffinches in autumn fly about in large flocks in the fields, they eat an enormous number of weed seeds. The young are chiefly fed with insects, especially with caterpillars. In the spring, when the seeds have germinated and the young corn is not yet ripe, the chaffinch feeds itself also on insects.

Group: **Subulirostres** (*Awl-beaked Perching Birds*).

Beak slender, awl-shaped, round in transverse section. A fully developed organ of voice. Feed almost exclusively on insects; there are only a few species which occasionally eat seeds. A few of them, however, sometimes devour juicy fruits (cherries, bird-cherries, elder-berries, juniper-berries, grapes). The birds belonging to this group, without exception, feed their young on insects. They are of service; even those species which occasionally do damage are useful on the whole.

There belong to the Subulirostres—

The **Wagtails** (*Motacilla*), *e.g.* the **White Wagtail** (*M. alba*), usually living in the neighbourhood of water, and seeking its insect food in the fields (often behind the plough), and in pastures and gardens.

The lark-coloured **Pipits** (*Anthus*).

The **Hedge Accentor**, or "Sparrow" (*Accentor modularis*),—in garden hedges, and woods, feeding sometimes on seeds.

The following "warblers:" **Nightingale** (*Daulias luscinia*), **Robin** (*Erithacus rubecula*), **Redstart** (*Ruticilla phœnicurus*), the **Lesser Whitethroat** (*Sylvia curruca*), **Garden Warbler** (*S. hortensis*), **Willow Wren** (*S. trochilus*), **Chiffchaff** (*S. rufa*), **Reed Warblers**

(*Acrocephalus streperus* and *A. arundinacea*), etc. The last-named live among reeds and rushes on the banks of fresh waters, and eat insects which do not affect agriculture and forestry; all the other warblers are useful.

Other examples of the Subulirostres are the **Golden-crested Wren** (*Regulus cristatus*), and the **Common Wren** (*Troglodytes parvulus*), which are of service to forestry and fruit-tree culture, but not to agriculture.

Most of the native thrush-like birds (*Turdus*), *e.g.* the **Blackbird** (*T. merula*), the **Missel Thrush** (*T. viscivorus*), the **Fieldfare** (*T. pilaris*), the **Redwing** (*T. iliacus*), and the **Song Thrush** (*T. musicus*), assist the farmer by devouring noxious insects and snails; but several of them occasionally do damage by poaching on cherries, grapes, currants, etc. Some of them (*e.g.* the Song Thrush and Blackbird) breed in almost all parts of Britain, others come here only in autumn or winter.

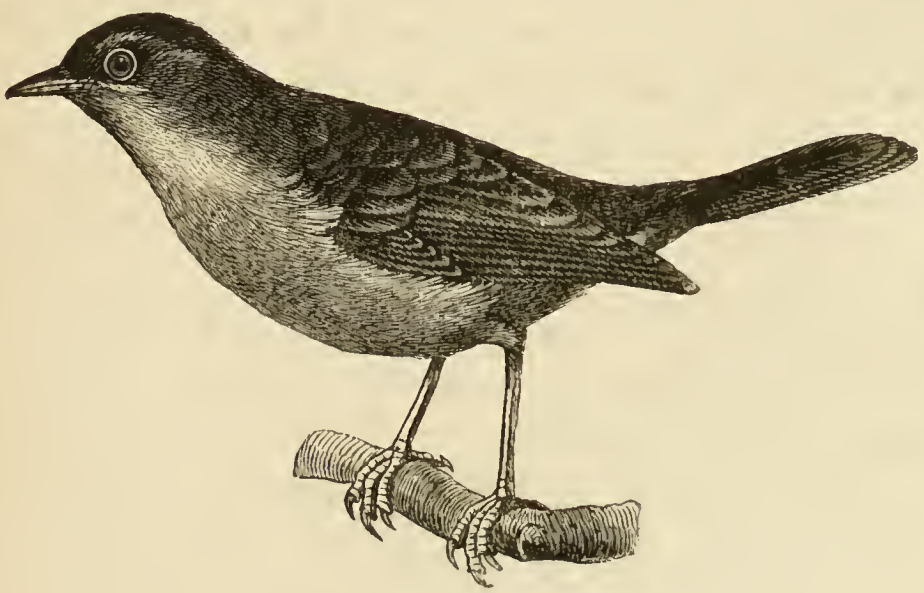

Fig. 38.—The Nightingale (*Daulias luscinia*).

Order: **Gyrantes** (Doves).

Body strongly built, somewhat thick-set. Wings long and pointed. Beak weak, with a cere at its

base; nostrils covered by gristly scales. Toes: three forwardly and one backwardly directed, free, *i.e.* without a web (as in poultry). The young are at first blind and naked. They are at first fed with a cheesy secretion of the glands of the crop; later, with grain softened in the crop. Doves always live in pairs. Nests careless, flat, of loosely arranged twigs; situated on tree-branches, rocks, and large buildings. Doves breed twice or thrice a year, laying two longish, shining white eggs.

Native British forms :—

1. **Wood Pigeon** (*Columba palumbus*, Fig. 39), from April to September scattered about in the woods, but after the breeding season wander about in flocks, and

Fig. 39.—The Wood Pigeon (*Columba palumbus*),

in winter travel further south, although many remain. It nests on horizontal branches, and feeds on seeds of fir and pine, acorns, beechnuts, also grain,

peas, vetches, rape-seed,—but seeds of many weeds as well (*e.g.* those of charlock, vetchling, spurry, cleavers). When the earth is covered with snow it often eats cabbage and the leaves of winter rape, but is also of some service.

2. The **Turtle Dove** (*C. turtur*) occurs on the edges of woods, especially those consisting of coniferous trees. Nests in the trees. For *food*, *use*, and *harm*, cp. the preceding species. Steals buckwheat grains from the fields.

3. The **Rock Pigeon** (*C. livia*) is the original stock of our races of domestic pigeons. It nests, as a resident, in the Mediterranean countries; as a migrant, on the rocky parts of the coasts of Great Britain and the Orkneys, Shetlands, and Faroe Islands.

Order: **Rasores** (Poultry).

Body strong, thick-set. Head small, often with naked, brightly coloured patches, with fleshy combs or with a crest of feathers. Tip of the upper beak bends over that of the lower one. No cere (cp. Doves). Wings short, rounded; flight heavy. Feet strong. Hinder toe small and usually attached to the tarsus higher up than the front toes. Claws blunt. A small web at the bases of the toes. The male of several species bears a spur on the tarsus. Birds of this order usually keep on the ground, scraping it in search of their food, which consists of seeds, berries, the green parts of plants, insects, worms, and snails. Young precocious (p. 51). Several domestic birds belong to the Rasores: pheasants, the various races of fowls, pea-fowls, guinea-fowls, turkeys.

The species living wild in Britain are game-birds. They are—the **Capercailzie** (*Tetrao urogallus*, Fig. 40), **Black Game** (*T. tetrix*), **Partridge** (*Perdix cinerea*), **Quail** (*P. coturnix*); none of them are particularly harmful or useful to agriculture.

The **Pheasant** (*Phasianus colchicus*, Fig. 41) was originally a native of the Caucasus, and shores of the Caspian Sea and Sea of Aral; it occurs wild in Central Europe. Pheasants are troublesome to the farmer, both by devouring the newly sown seed and by scratching up the fields.

Fig. 40.—Male and Female Capercailzie (*Tetraourogallus*).

Order: **Grallatores** (Wading-Birds).

The species here included differ very much among themselves; but all seek their food, which is almost exclusively of animal nature, at the water-edge (rivers,

brooks, lakes, ditches, canals, seashore) or in damp places (damp meadows and ploughed fields, moors,

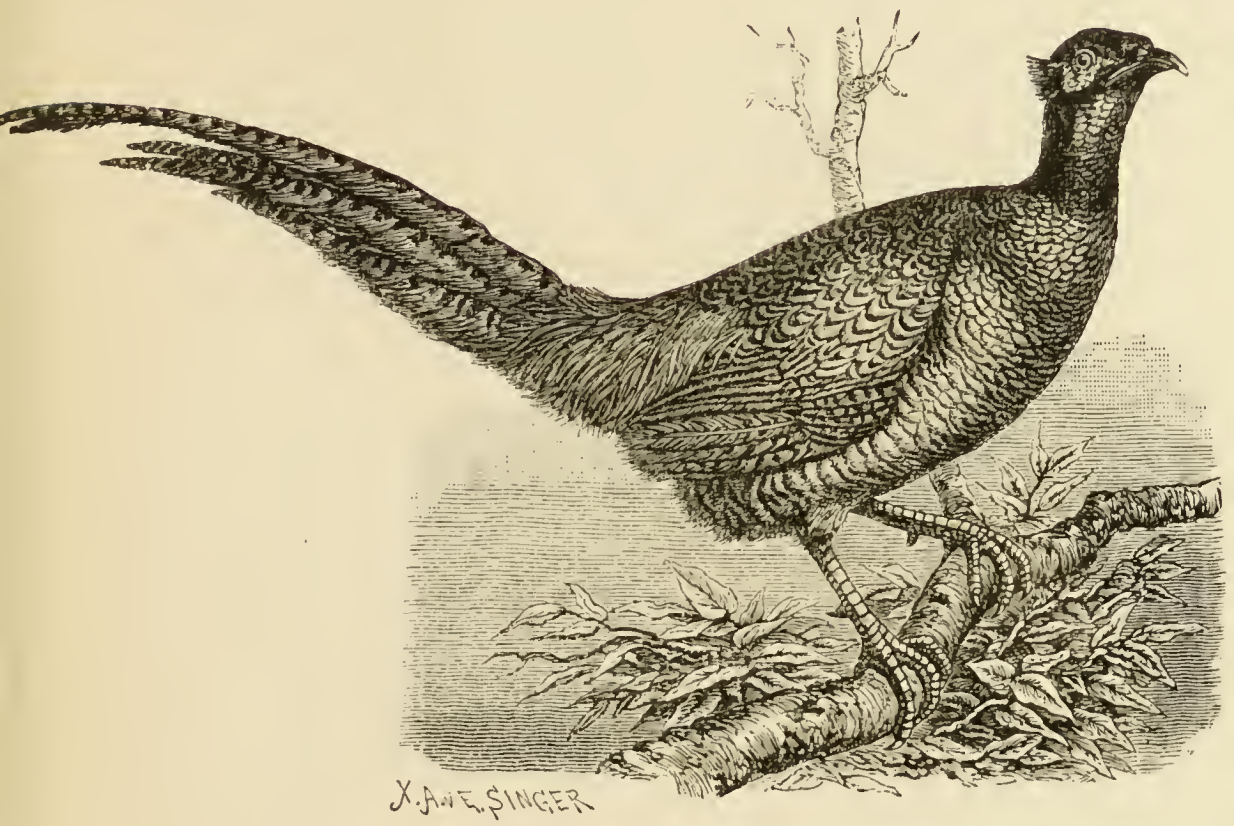

Fig. 41.—The Pheasant (*Phasianus colchicus*).

swamps). They are, therefore, adapted to wading, and for this purpose have a long featherless tarsus, while the lower half of the long shank is quite bare and covered with horny scales. In flight the wading-birds do not draw their legs up to their body, as is the case with the birds already spoken of, but stretch them out behind to their full length. Monogamous. Young precocious (p. 51), except in storks and herons when they are nestlings. The shore-dwellers eat fish, bivalve molluscs, etc.; only those species living on damp meadows and fields are of use to agriculturists, by devouring insects, snails, and worms. These are indicated by the letter *u* in the following list of the commonest native kinds:—

Coot (*Fulica atra*); **Water Hen** (*Gallinula chloropus*); **Corn Crake** (*Crex pratensis*, u); **Plovers**

(*Charadrius*, u); **Pewit** or **Lapwing** (*Vanellus cristatus*, u); the **Snipes** (*Scolopax*); the **Curlews** (*Numenius*, u); the **Stints** (*Tringa*); the **Godwit** (*Limosa ægocephala*,

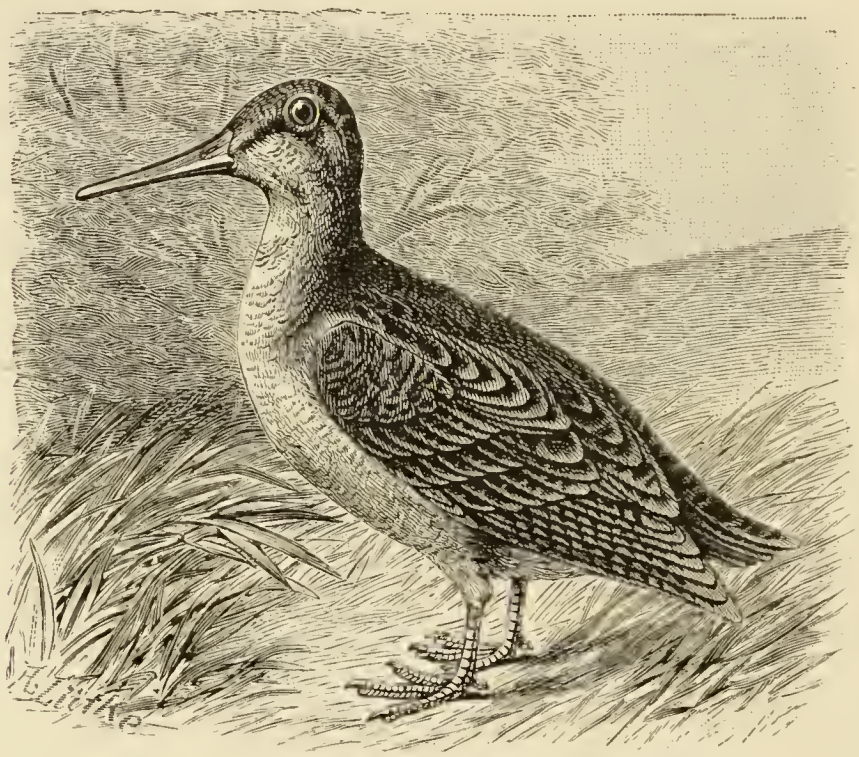

Fig. 42.—The Woodcock (*Scolopax rusticola*).

u); the **Sandpipers** (*Totanus*, u); the **Heron** (*Ardea cinerea*).

Order: **Natatores** (Swimming-Birds).

These birds are distinguished by their swimming powers and corresponding organization. Legs usually set on far back, shorter than the body. The feet in particular are adapted for swimming. In some swimming-birds each of the forwardly directed toes has a webbed margin ("split swimming feet," Fig. 43); in others, the three front toes are all united by a web (Fig. 44), while the hind toe is either small or wanting ("swimming feet"); lastly, there are some in which all the toes are forwardly directed and united by a common web ("oar-feet"). The plumage of swimming-birds is compact, and always kept greasy by the

secretion of the oil-gland. I shall speak of two families only.

Family: **Lamellirostra** (*Ducks*).

The inner margin of the beak is covered by skin, thrown into transverse ridges or tooth-like projec-

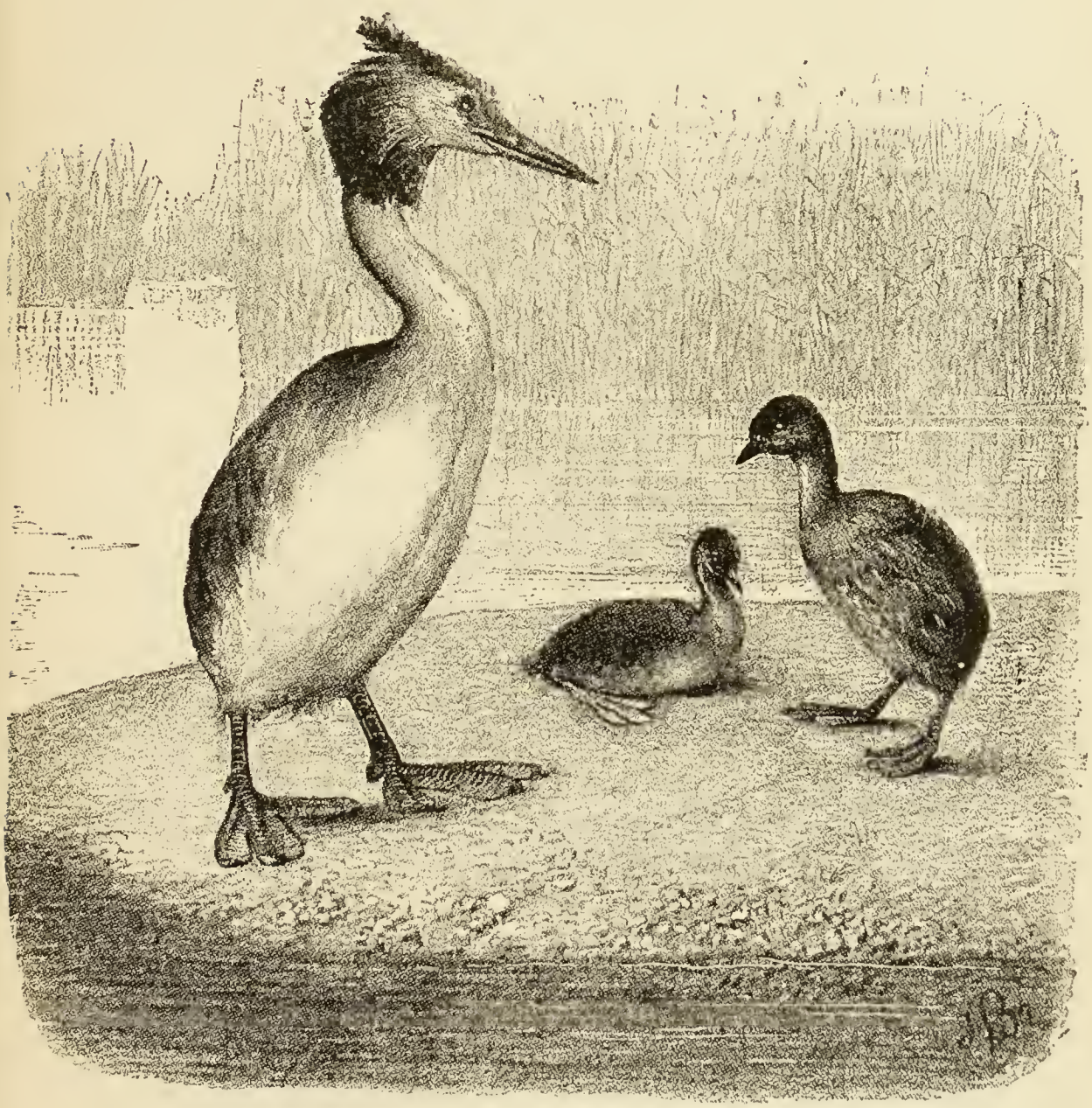

Fig. 43.—Crested and Little Grebes (*Podiceps cristatus* and *minor*).

tions. Swimming feet (Fig. 44). Tolerably long wings; remarkable powers of flight. Feathers soft. These birds mostly affect shallow fresh water, in

which they get their food by grubbing in the mud, the soft skin of the beak serving as an organ of touch. Polygamous. Young precocious (p. 51).

Here belong — the long-necked **Swans** (*Cygnus*) and the thick short-necked **Geese** (*Anser*), in which the beak is higher than broad at its base; the **Swimming Ducks** (*Anas*) with broader beaks, the **Diving Ducks** (*Fuligula*), and **Goosanders** (*Mergus*) with a broad hanging web to the hind toe. None of these birds are useful, while wild geese and ducks are harmful.

Three species of wild **Geese** (**Grey Goose** = *Anser*

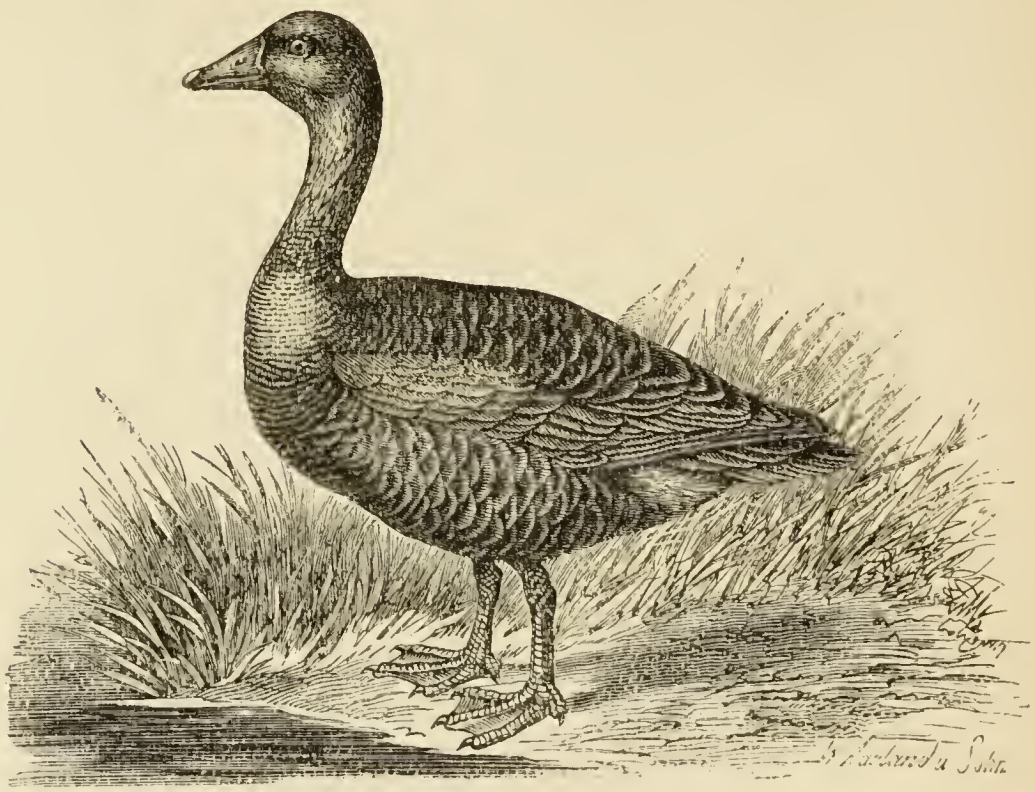

FIG. 44.—Goose (*Anser cinereus*).

cinereus, **Bean Goose** = *A. segetum*, **White-fronted Goose** = *A. albifrons*) chiefly breed in Eastern or Northern Europe, and only come to Britain in autumn or winter, flying about in flocks. They eat the grass in low-lying meadows, and even pull it up by the roots; in the cultivated fields they devour winter corn and winter rape, and tread down more with their clumsy feet than they eat. They are also harmful to

vegetable growth, owing to the very caustic nature of their dung, which is often deposited in large quantities in one place. In regions where they breed they also devour both ripe and unripe grain. Where they only occur in autumn, they scrape potatoes, turnips, and carrots out of the ground in order to eat them. Flocks of geese fly in a slanting line or in the form of a ploughshare.

Among *Swimming Ducks* damage is only done by the **Wild Duck** (*Anas boschas*). It breeds wherever there are fresh waters. Nests amongst grasses or swamp-plants, or in a tree. The wild ducks remain the whole winter as long as the waters are not frozen, otherwise they go off for a short time to the south. Food: the tops of stems, buds, leaves of various water-plants, also barley, oats, and other grain; water-insects, fish, and fish-spawn. These ducks also do damage in cornfields by treading down and cracking the plants.

Family: **Longipennes** (*Gulls*).

Usually swimming feet. Legs tolerably long, adapted for wading (Fig. 45). Wings long, pointed. Beak laterally compressed. Young nestlings (p. 51). Breed in larger or smaller flocks, usually on the coast, occasionally on the margin of fresh waters. They chiefly feed on fish, worms, molluscs, and crustacea; sometimes, in the case of a few species, on young birds and eggs, as well as mice and other small mammals. Gulls are usually of no importance in agriculture; but the **Black-headed Gull** (*Larus ridibundus*), which breeds on the banks of lakes and rivers, devours many cockchafers and other noxious insects. The **Herring Gull** (Fig. 45), **Kittiwake** (*Larus argentatus* and *L. tridactylus*), and a few other species, which breed on the coast, sometimes show themselves inland, especially in stormy weather; they then pursue field-voles, and catch many injurious insects.

Besides the true **Gulls** (*Larus*), I will only mention the **Sea Swallows** (*Sterna*), with forked tails.

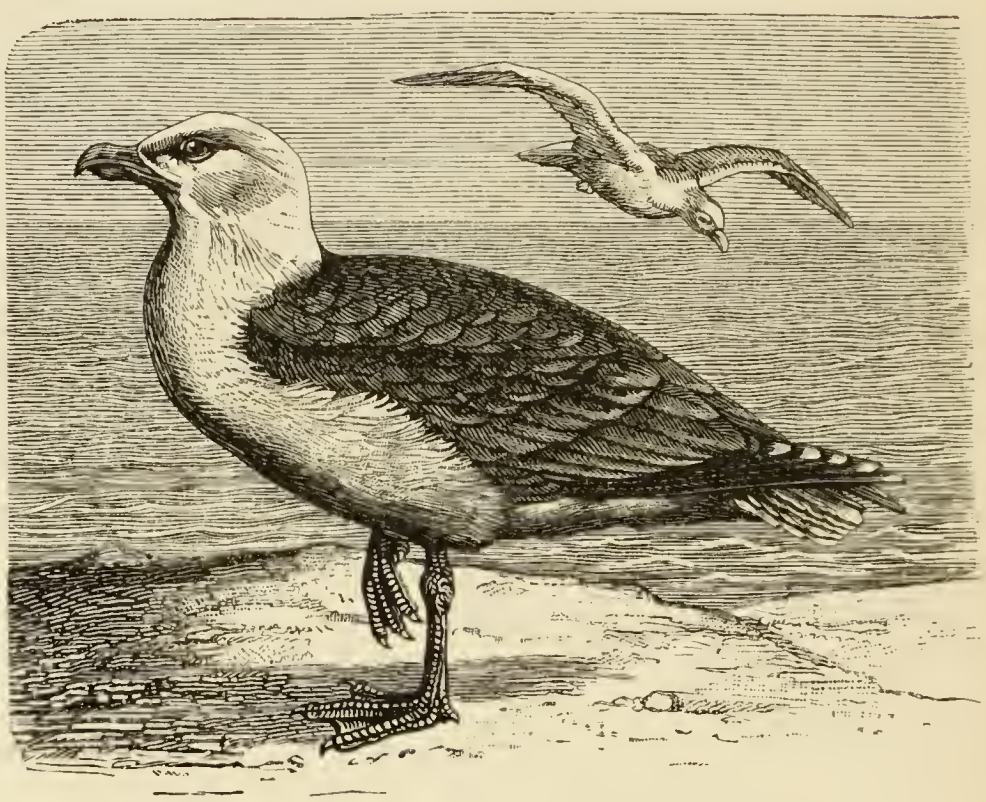

Fig. 45.—Herring Gull (*Larus argentatus*).

CLASS III.: **REPTILIA** (REPTILES).

Cold-blooded Vertebrates (p. 19). The heart has the same structure as in Mammals and Birds, but the left and right ventricles are usually only incompletely divided from one another (p. 20). The body is invested with horny scales or with bony plates covered by a horny layer. Reptiles are very unlike Birds in appearance, but present many essential points of resemblance to them in their skeleton; indeed, during earlier geological times, there were transitional forms between the two classes. The structure of the reptile egg, too, is very similar to that of the bird's egg; but the first has no lime-salts deposited in its shell. The egg is not hatched out by the animal itself, but exposed to

the heat of the sun or to the warmth developed by decaying vegetable matter. Several reptiles (adder, for example) keep their eggs in their bodies till the young escape. Reptiles have either no limbs (snakes,

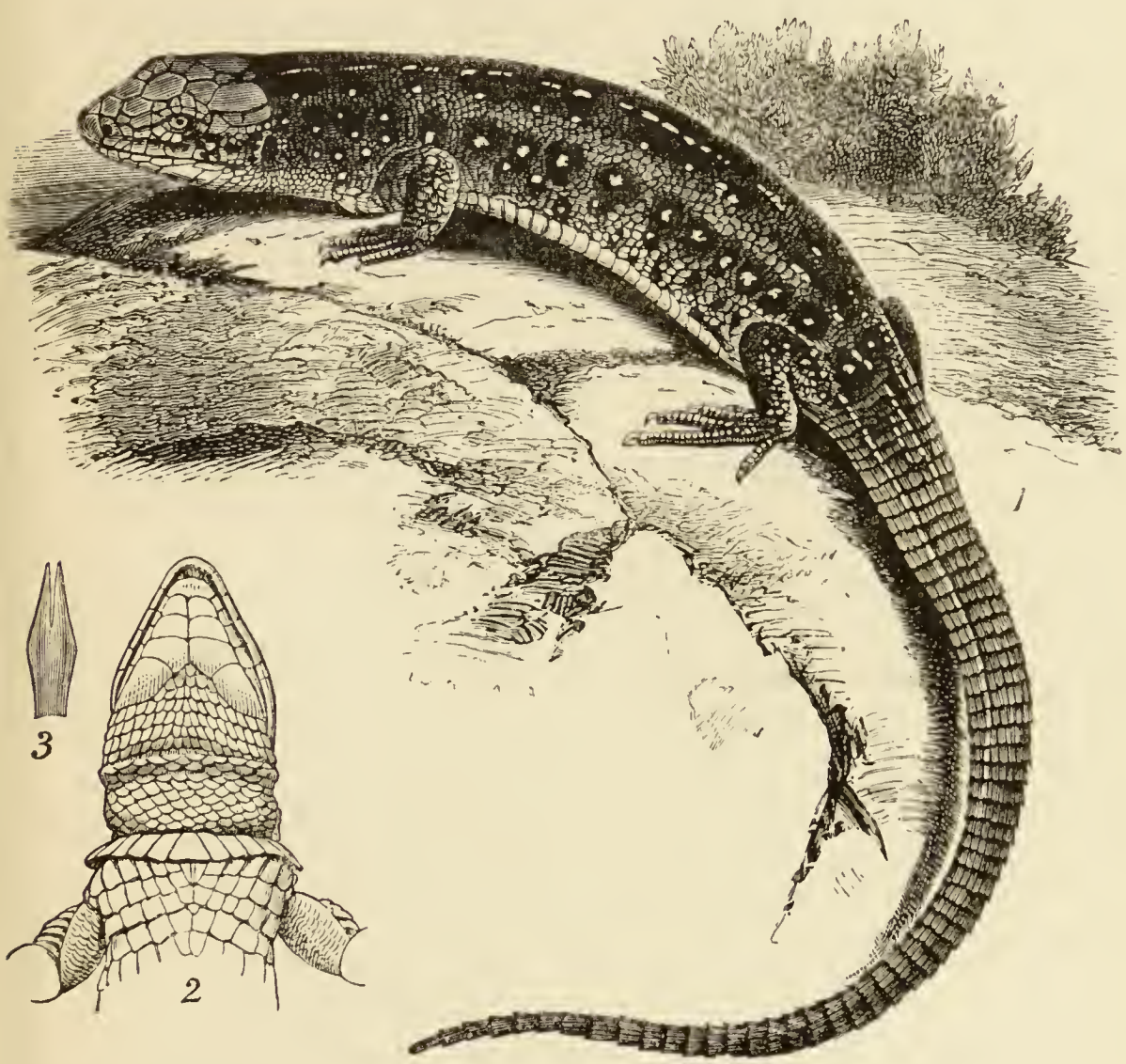

FIG. 46.—Common Lizard (*Lacerta agilis*); 2, head of the same from below; 3, tongue.

a few lizards), or, at any rate, the limbs are not well developed, and are so placed that the body does not rest upon them, but is slung between them.

The Reptilia are divided into the Orders of **Crocodilia** (Crocodiles), **Chelonia** (Turtles and Tortoises), **Lacertilia** (Lizards), **Ophidia** (Snakes).

Our native reptiles have no agricultural importance. I will, however, briefly mention the **Adder**

(*Pelias berus*, Fig. 47), as it is dangerous to man. Head broad; tail much smaller than the hinder end

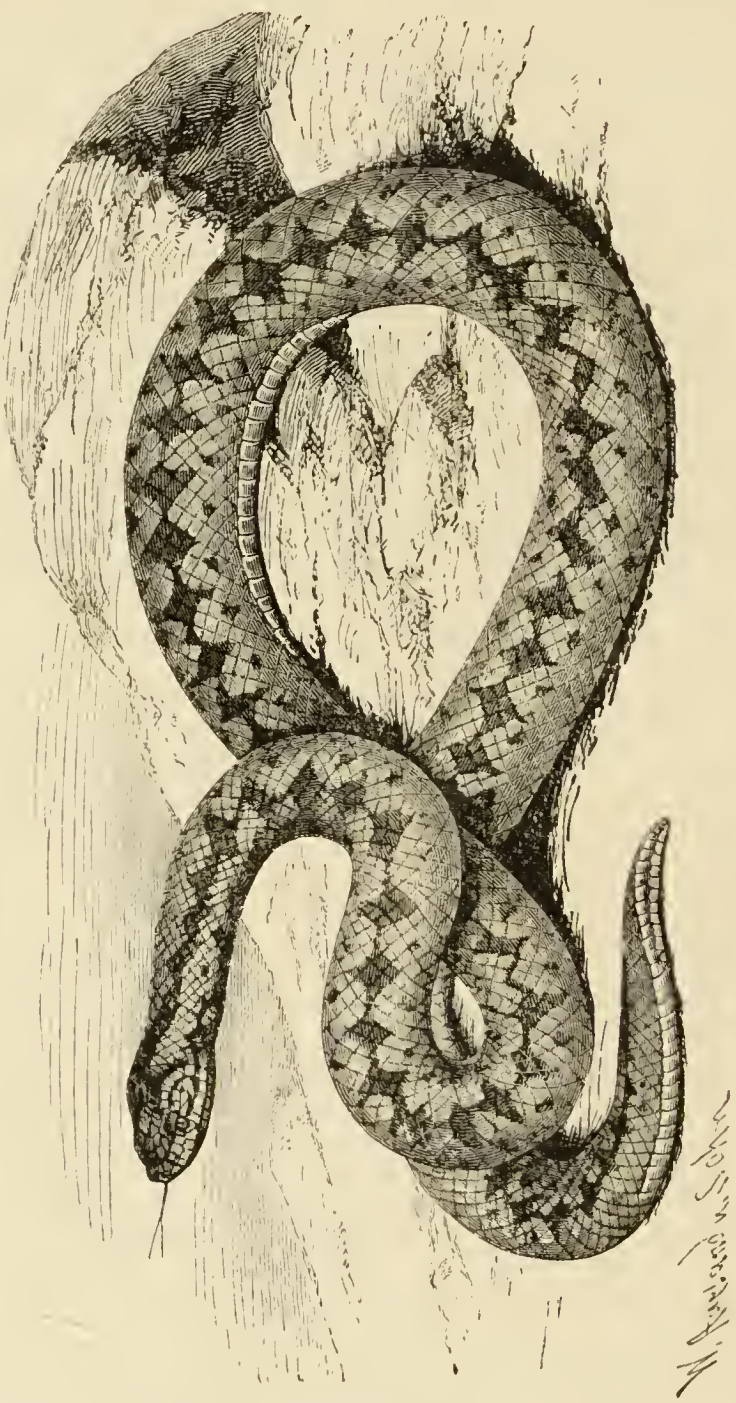

Fig. 47.—The Adder (*Pelias berus*).

of the body. Colour greenish grey or brownish. A black zigzag band runs along the dorsal side of the body. Length about twenty inches. The two hook-shaped poison-fangs are found in the front of the upper jaw; opening the mouth widely causes them to be erected. They are traversed by poison-canals through which the poison flows immediately into the

two bloodless wounds. The adder lives in woods and on mountain slopes, where it devours mice. The poison has a decomposing action on the blood; it causes fever, and swelling of the part bitten, as well

Fig. 48.—The Grass Snake (*Tropidonotus natrix*).

as sometimes of the neighbouring parts. The bite may be fatal. Alcohol is spoken of very highly as a remedy.

The native **Ringed Snake** (*Tropidonotus natrix*, Fig.

48), three feet long, is bluish with belly flecked with black and white; a yellow and a black band on the neck. It is fond of going into the water, and eats frogs,

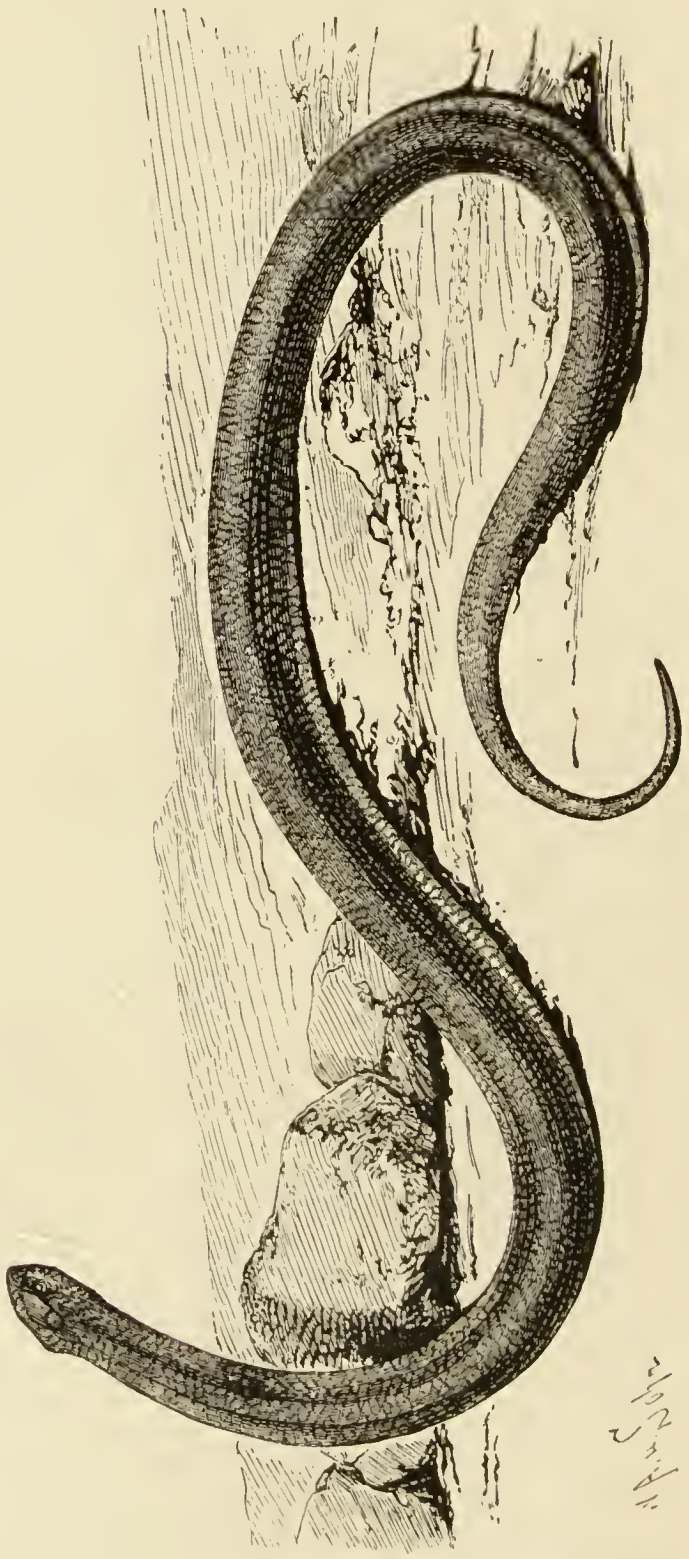

Fig. 49.—Blindworm (*Anguis fragilis*).

newts, and insects. The **Smooth Snake** (*Coronella lævis*), two feet long, is brown, with black patches on

the back, which, however, do not form a continuous band. Head dark velvety black. Devours lizards and blindworms. The **Blindworm** (*Anguis fragilis*) is indeed snake-like, or rather worm-like (Fig. 49), but nevertheless belongs to the lizards, with which its internal structure agrees.

CLASS IV.: **AMPHIBIA** (AMPHIBIANS).

Cold-blooded Vertebrates (p. 19). The heart has only one ventricle and two auricles (cp. p. 21). The skin is naked, damp, usually slippery and smooth; it helps in respiration. Although several Amphibians resemble various Reptiles in outward appearance (Newt and

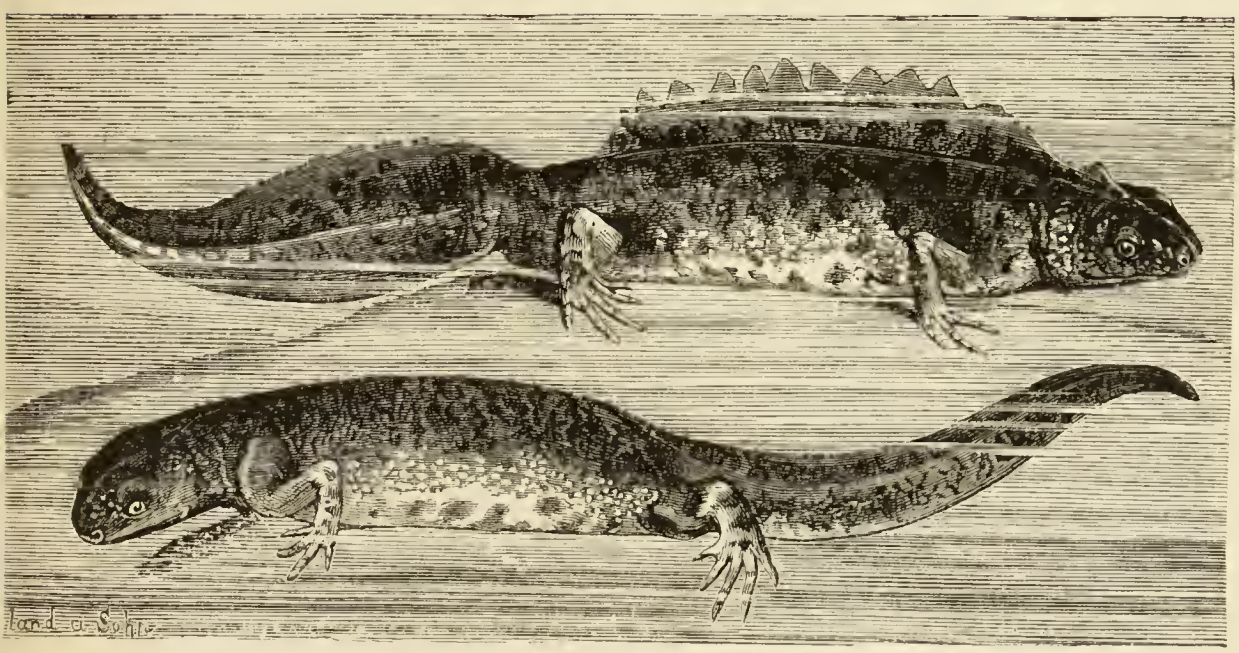

Fig. 50.—Great Crested Newt (*Triton cristatus*); male above, female below.

Lizard, Figs. 50 and 46), the structure of the skeleton is quite different. Upon the whole, Amphibians resemble fishes more closely, and they breathe by gills when they are young, which strengthens the agreement. They undergo a metamorphosis. The just hatched young at first hold fast by suction to the jelly of the spawn; they have external gills. They

quickly develop a membranous margin to the body, especially round the tail, which consequently forms a sort of oar. Meanwhile internal gills develop, and the external ones disappear. The larvæ are now fish-like ("tadpoles"). The limbs quickly grow out, the lungs develop, the tail shrivels up, and the animal leaves the water. Even the adult, however, lives among damp surroundings. In the adult state the Amphibians feed on insects, worms, and snails; many species are exceedingly useful owing to this.

Amphibians are divided into two orders, the *Urodela* (Newts, etc.) and the *Anura* (Frogs and Toads). To the first belong the **Great Crested Newt** (*Triton cristatus*) and the **Common Newt** (*Lissotriton tæniatus*).

Fig. 51.—Common Frog (*Rana temporaria*).

Examples of the Anura are the **Edible Frog** (*Rana esculenta*), the brownish **Common Frog** (*R. temporaria*, Fig. 51), the **Common Toad** (*Bufo vulgaris*), and the **Natterjack** (*B. calamita*, Fig. 52).

Both frogs and toads do good by devouring many noxious insects, and also, in particular, snails. Toads are often kept in greenhouses for this purpose; and

in the research garden attached to the Rouen entomological laboratory the snails were entirely exterminated in 1891, as a result of introducing a hundred toads and ninety frogs.

FIG. 52.—Natterjack (*Bufo calamita*).

CLASS V.: **PISCES** (FISHES).

Cold-blooded Vertebrates (p. 19), which breathe by gills during their whole life. The heart consists only of a single ventricle and a single auricle (p. 18). The head passes immediately into the body without any intervening neck. Fishes move chiefly by means of the tail, at the end of which there is a tail-fin. This and the dorsal and anal fins lie in the median plane of the fish, while the pectoral fins, which are attached to the skull in bony fishes, and also the ventral fins, are paired structures more or less comparable to the fore and hind limbs of higher vertebrates. The skeleton of most fishes (pike, perch, carp, eel, plaice) is bony; but in a few subdivisions of fishes

(sharks, skates, sturgeons, lampreys) it is cartilaginous. The skin is usually covered with thin translucent scales; but there are fishes with a smooth skin (lampreys), with prickle-like dermal ossifications

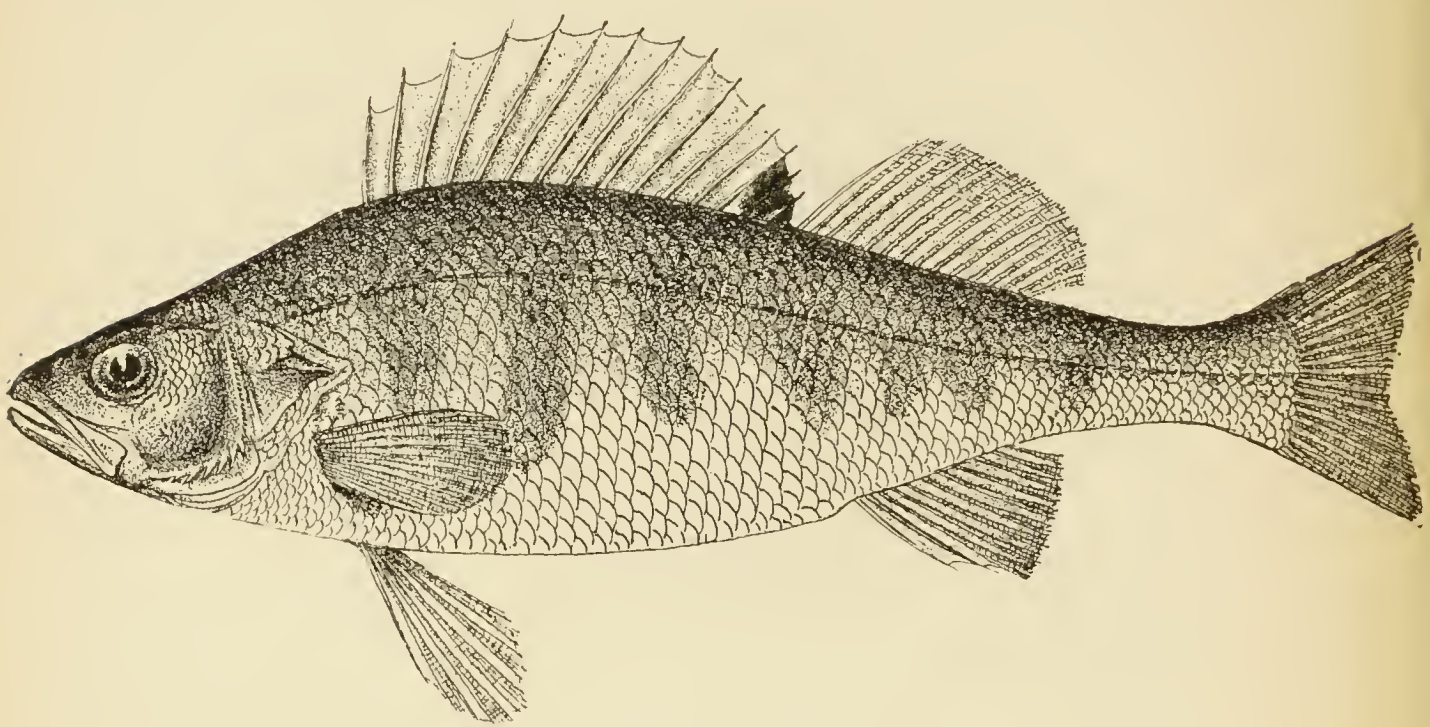

Fig. 53.—The Perch (*Perca fluviatilis*).

(sharks), and with rhomboidal bony plates (sturgeons). As Fishes are without exception aquatic, there is no need for me to treat more specially of them here.

Second Sub-Kingdom: ARTHROPODA
(Jointed-limbed Animals).

The body of an Arthropod is bilaterally symmetrical (cp. p. 16), and consists of a number of joints (Fig. 55), not equally numerous in all members of the sub-kingdom. These joints or segments lie one behind the other, and are at first alike; but as in the course of further development they become adapted to various functions, the difference between them becomes greater. Compare the Wood-borer represented in Fig. 54, 2, with the young form of the

same animal (Fig. 54, 1). The segments often fuse together, which brings about the formation of a smaller number of subdivisions to the body; or even all the segments may become united (mites). In the last case the Arthropod characters are only to be seen in the jointing of the limbs. Segmented animals (*e.g.* the common earthworm) are also found among the worms (Sub-kingdom III. of the Animal Kingdom);

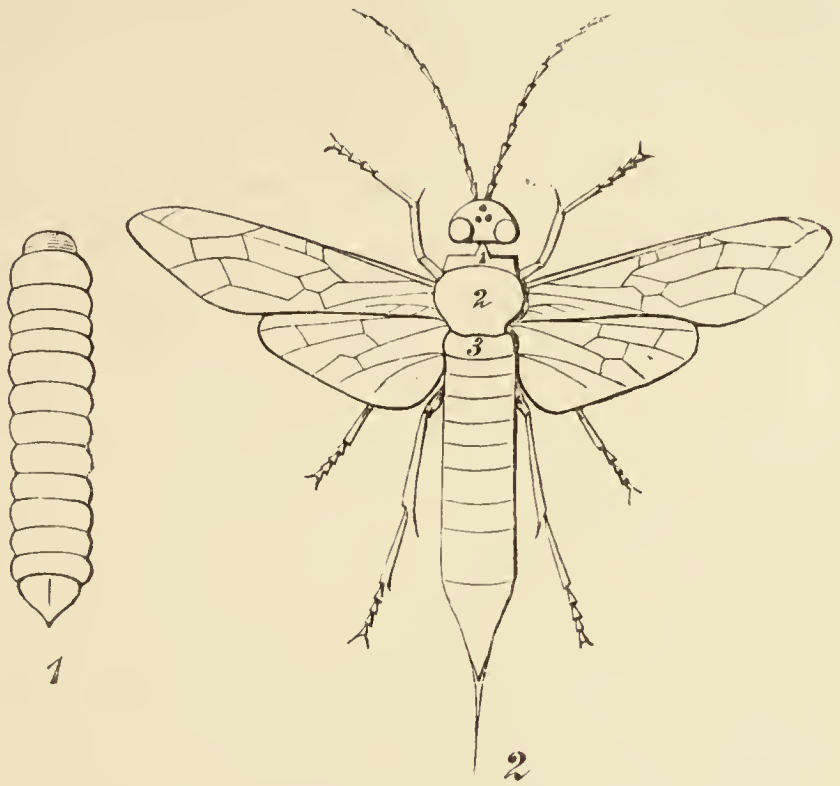

FIG. 54.—Wood-borer (*Sirex*); 1, larva; 2, adult insect.

but these worms have either no limbs, or only small unjointed foot-stumps, never jointed limbs as in the Arthropods. These last are limbless or with unjointed foot-stumps only when young; when adult they always have jointed limbs. The head of Arthropods bears several successive pairs of jaws, which move to and fro from one side towards the other. The covering of the body consists of hard protective pieces; it is only in the young condition that the skin of several species is soft. Arthropods have no internal skeleton; the muscles are attached to the skin. The central part of the nervous system (p. 10), which consists in

Vertebrates of brain and spinal cord, lies in Arthropods almost entirely on the ventral side. In the head is situated the cerebral ganglion, a large nervous mass resting on the gullet, and giving off nerves to the eyes and feelers. Besides this, there is a ventral nerve-

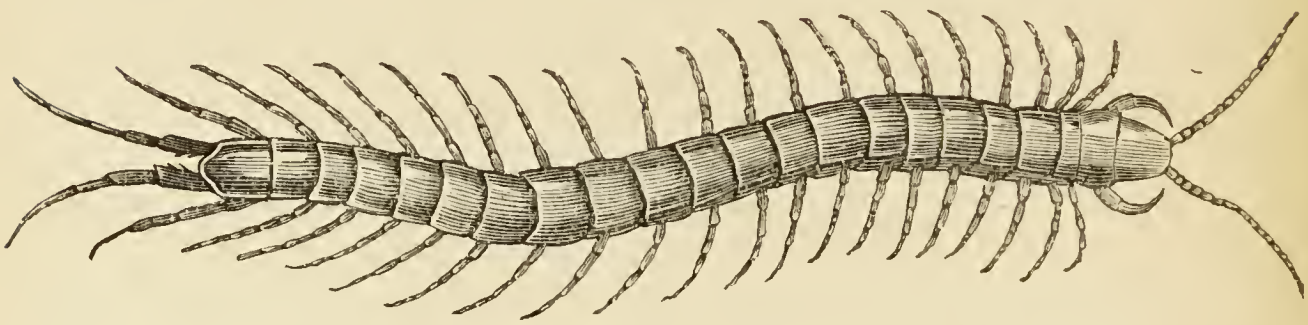

Fig. 55.—The Large Centipede (*Scolopendra morsitans*).

cord on the ventral side of the animal, running below the gut, and made up of several pairs of ganglia, united with one another by means of nerve-fibres. The ganglia of the ventral cord send their nerves to the jaws, limbs, muscles, viscera, etc. The cerebral ganglion is connected with the first ventral ganglion by means of a cord on each side of the gullet (Fig. 56), so that a ring-like structure is formed. The breathing organs are gills in some Arthropods (the Crustacea, *e.g.* crayfish, crabs); insects and centipedes breathe by air-tubes or tracheæ, while the respiratory organs of spider-like animals, when these do not breathe entirely by means of the skin, are more or less strongly modified tracheæ. The structure of the tracheal system is generally as follows: on each side of the body there is a row of breathing-holes, or stigmata, through which the air can enter the tracheæ; these are very much branched, so that they finally become very fine tubes investing the various organs,

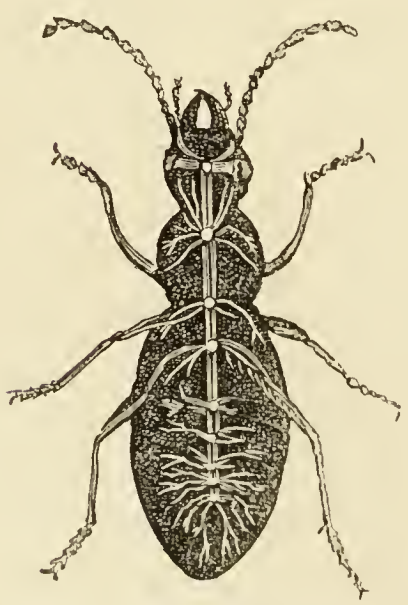

Fig. 56.—Ground Beetle, with nervous system drawn in white.

which in this way obtain the requisite amount of oxygen. The stigmata on one side of a caterpillar are clearly shown in Fig. 60, and those of a hornet larva in Fig. 61.

Four classes belong to this sub-kingdom: Insecta (Insects), Myriapoda (centipedes, etc.), Arachnoidea (spiders, scorpions, etc.), Crustacea (crayfish, crabs, lobsters, etc.).

CLASS I.: **INSECTA** (INSECTS).

Breathe by tracheæ (cp. p. 84). The segments fuse into three body regions (Fig. 57). These are—

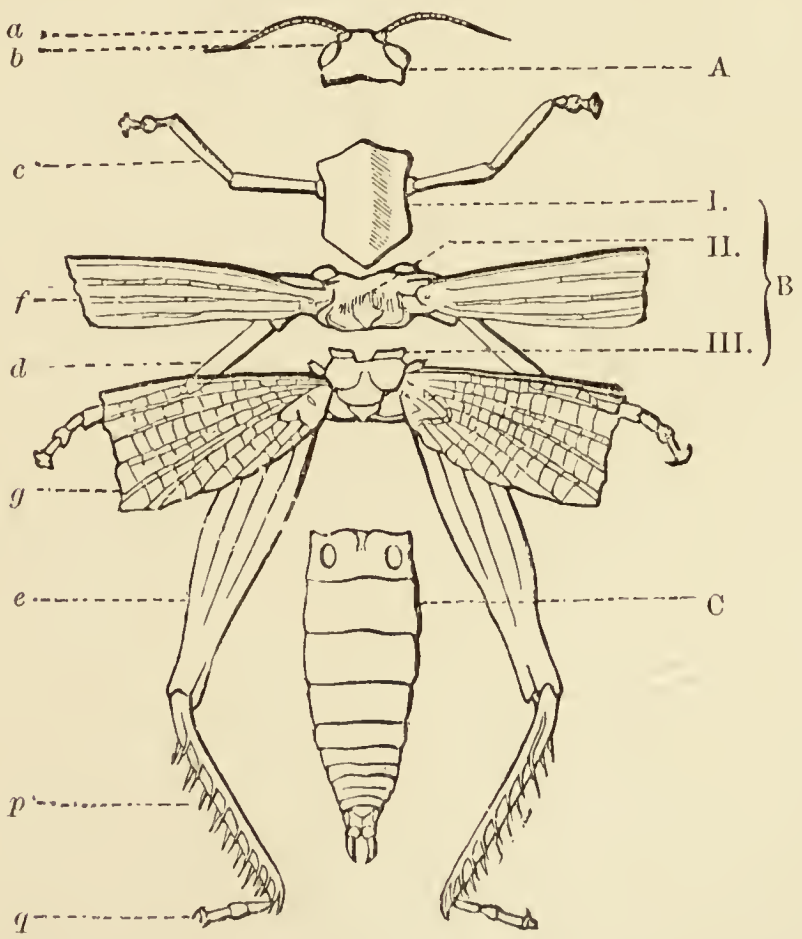

Fig. 57.—A Grasshopper, with the different regions of the body separated from one another. A, head; B, thorax: *I.*, prothorax; *II.*, mesothorax; *III.*, metathorax; C, abdomen; *a*, antennæ; *b*, eyes; *c*, *d*, *e*, legs; *f*, *g*, wings; *p*, shank; *q*, foot.

(1) the *Head*, bearing the eyes, feelers (antennæ), and jaws; (2) the *Thorax*, composed of three fused segments, of which the first (prothorax) bears a pair of legs, while the second (mesothorax) and third (metathorax) not only bear a pair of legs each, but also sometimes a pair of wings in addition; (3) the *Abdomen*, which possesses no limbs, and of which the number of segments is not always the same. These three regions of the body perform different functions; the head is concerned with sensation and the taking up of food, the thorax with movement, while the abdomen contains the organs of digestion and reproduction. I will now deal somewhat more fully with the different body-regions of an insect.

Head.—Almost all insects have in the adult state a compound eye, *i.e.* an eye made up of a large number (up to ten thousand) of smaller eyes. In many insects one finds in addition to this a few simple eyes on the top of the head. The feelers are very unlike in different insects; they serve as organs of touch, and perhaps also help some other sense. The mouth-parts consist of three pairs of jaws, of which the first (the mandibles) and the second pair (maxillæ) are freely movable from side to side, while the third consists of two jaws immovably fused together (lower lip, or labium). A downward projection of the skin of the head (the upper lip, or labrum) overhangs the three pairs of jaws (Fig. 58). In insects which feed on solid matters, tearing or chewing them, the jaws are short and sharp-edged (biting mouth-parts); in those which take up fluid food (blood, the juices of plants, etc.) they are elongated, and adapted for licking, sucking, or piercing.

Thorax.—The names of the parts of the legs are for the most part those used in the case of mammalian limbs; though the similarity between the limbs of Mammals and Insects is quite superficial. The following parts are distinguished in the leg of an insect:

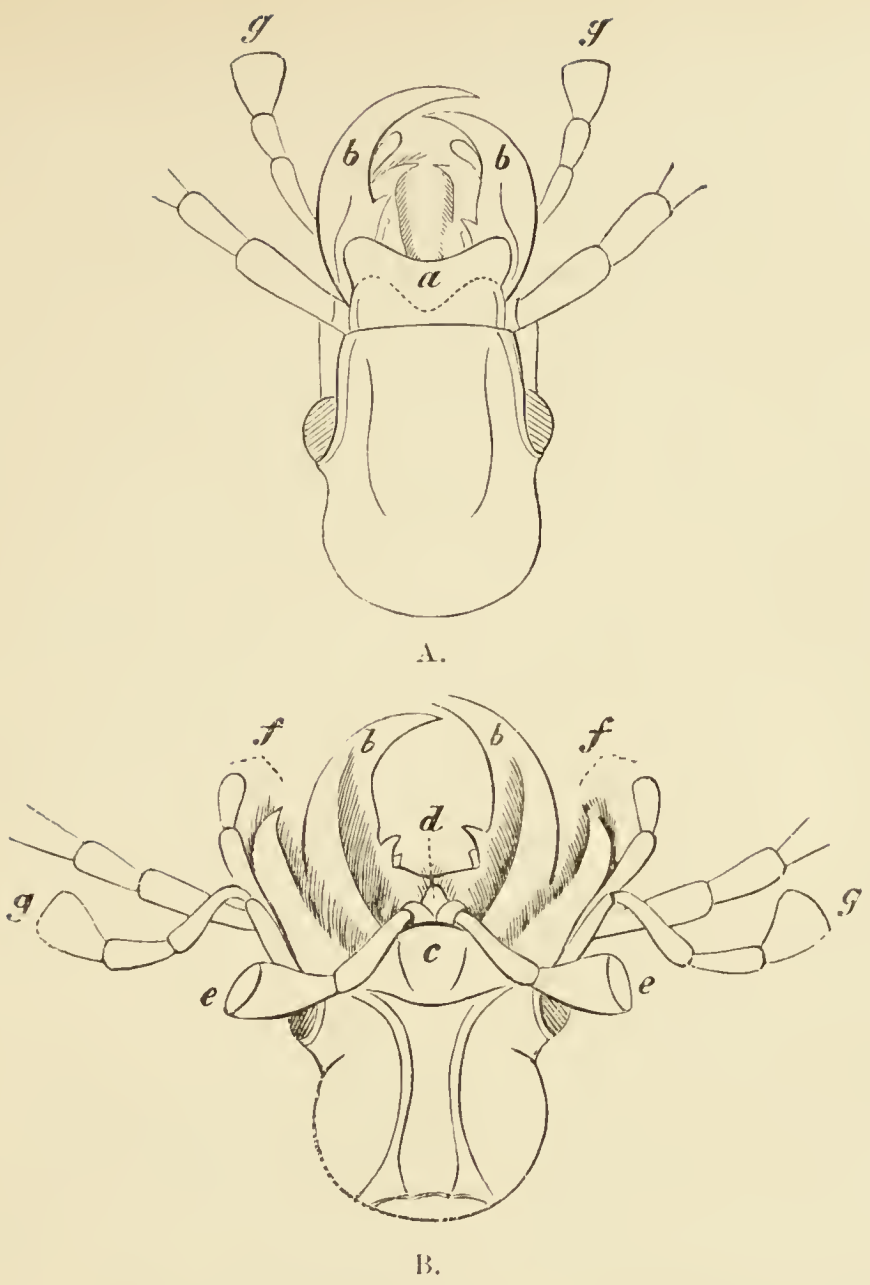

Fig. 58.—Head and Mouth-parts of a Ground Beetle, enlarged four times. A, from above; B, from below. *a*, labrum; *b*, mandible; *f*, maxilla with palpi (*g*); *c*, labium with palp (*e*).

(1) the generally spherical hip (*coxa*) (Fig. 59, *a*); (2) the very short *trochanter* (*b*); (3) the elongated thigh (*femur*) (*c*); (4) the shank (*tibia*) provided with movable spines at its tip (*d*); (5) the three- to five-jointed foot (*tarsus*) (*e*), whose last joint ends in claws, and often also in flap-like outgrowths. The *Wings* are expansions of the skin, which consist of two layers. There are tracheæ between the upper and lower lamellæ. At first (in the pupa) the wings are folded

up; but the forcing of air into the tracheæ quickly causes them to unfold. A firm substance is now

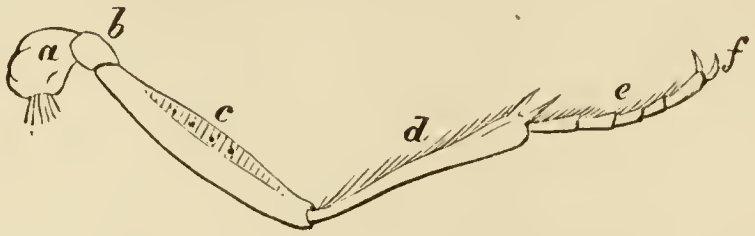

Fig. 59.—Leg of a Ground Beetle (× 2).

deposited in the larger tracheæ, which are thus converted into veins or ribs giving support to the wings. In beetles the fore wings are quite hard and horny, and serve for protecting the delicate hind-wings and soft back rather than for flight; they are therefore named "wing-covers" (*elytra*). In many insects the fore wings (wasps) or the hind wings (beetles, grasshoppers) are folded when at rest.

The *abdomen* only bears organs of movement in caterpillars (Fig. 60) and a few other insects in the

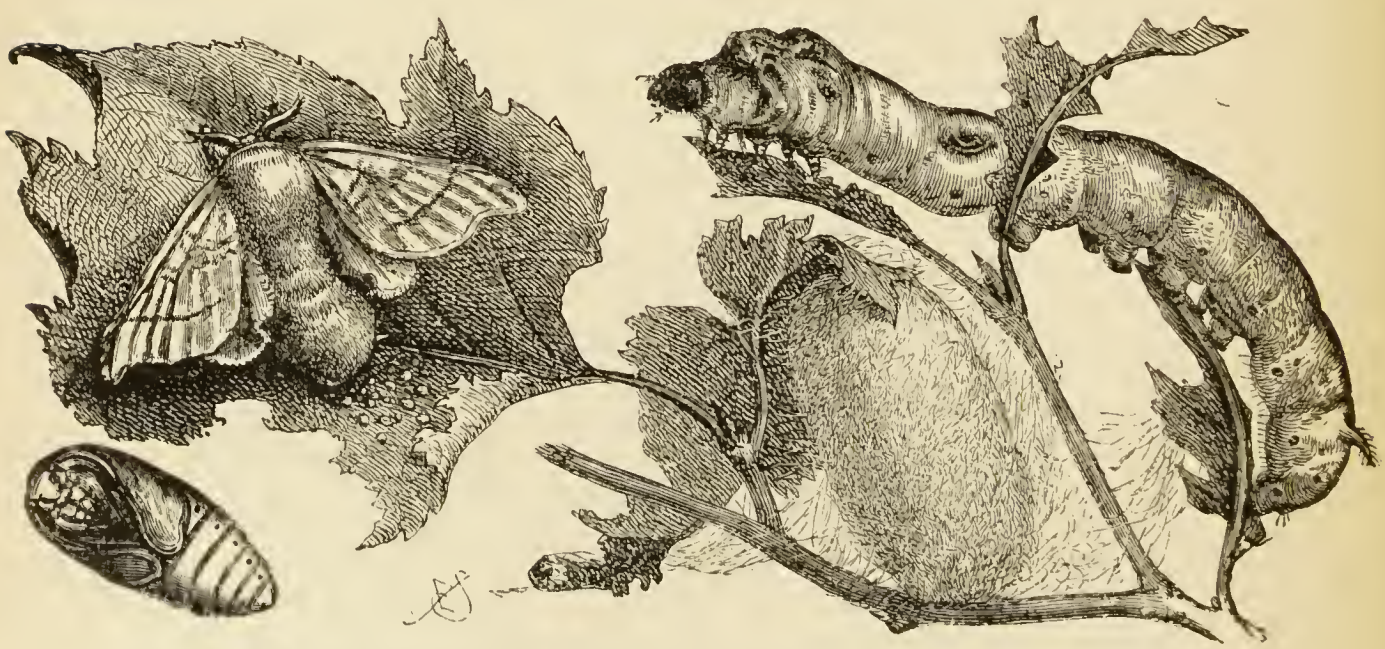

Fig. 60.—Silkworm Moth (*Bombyx mori*). Female moth, caterpillar, pupa and cocoon.

young condition, and in these cases they are not jointed like the true legs or "thoracic feet," but unjointed pro-legs or "abdominal feet." In the adult

insect the abdomen may have thread-like (mole-cricket) or pincer-like (earwig) appendages; or appendages used in egg-laying (ovipositors, *e.g.* Locust).

Most insects have great powers of reproduction. A few bring forth living young, but most insects lay eggs. It is only in a few (*e.g.* lice) that animals exactly like their parents are hatched from the eggs; the large majority of insects pass through a *change*, or *metamorphosis*.

A distinction is drawn between *complete* and *incomplete* metamorphosis. It is said to be complete when the insect passes through a stage in which it takes up no food, and, as a rule, moves but little. In this condition of almost complete rest the insect is called a "pupa" (Figs. 60, 61, 65). The metamor-

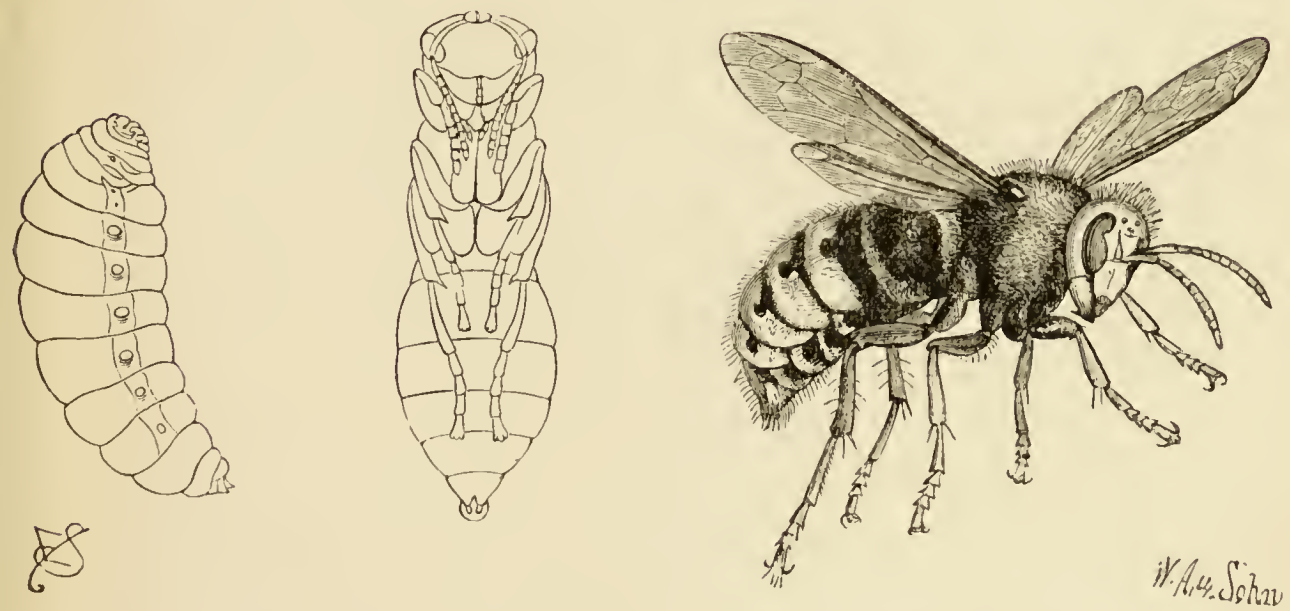

FIG. 61.—The Hornet (*Vespa crabro*), with larva and pupa.

phosis is called incomplete when the insect does not pass through a pupa stage, and therefore feeds and moves during all the periods of its development, merely altering its form somewhat during its various moults (Fig. 62).

The word "moult" must here be explained. The covering of the skin of Arthropods consists of hard

parts incapable of being stretched. At the end of a definite period of time this firm covering is stripped off and replaced by a new investment, soft at first,

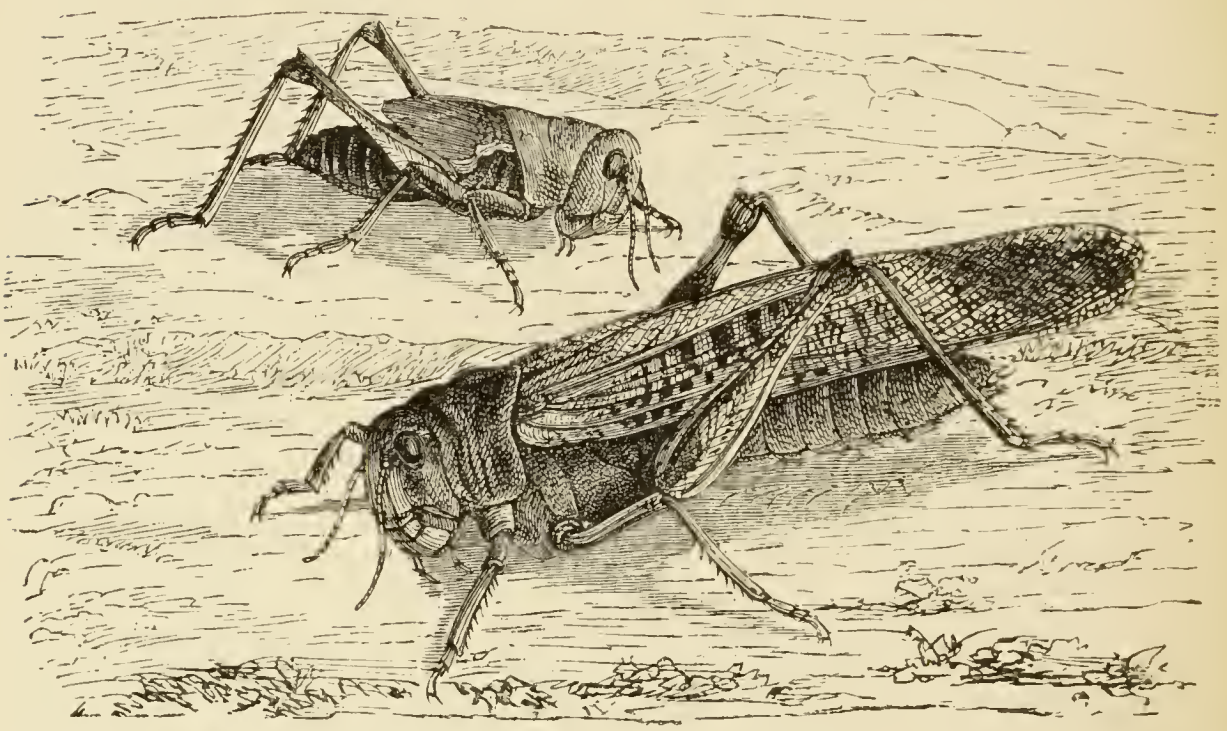

FIG. 62.—The Migratory Grasshopper (*Acrydium migratorium*). Larva and adult female.

but afterwards becoming hard. In this way growth can be effected in spite of the hard integument. Everyone must have noticed at some time or other the moulting of caterpillars.

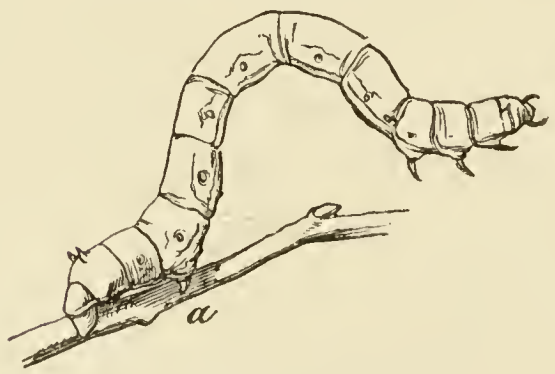

FIG. 63.—Looper Caterpillar.

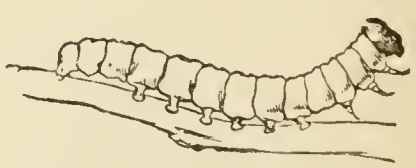

FIG. 64.—False Caterpillar.

In insects with incomplete metamorphosis the form of the animal alters a little at every moult, becoming more and more like that of the adult insect. In the last moult but one small imperfect wings appear

(Fig. 62, *left*), and fully developed wings are only present after the last moult. The ovipositors of female insects, in those cases where the metamorphosis is incomplete, first appear as fully developed organs in the perfect condition of the animal, but begin to develop in the preceding stage. In cases of this kind of metamorphosis the young insect ("larva") closely resembles the adult in form even in the first stage of development. In insects undergoing complete metamorphosis the difference between larva and adult insect (imago) is much greater (Figs. 60, 61, 65).

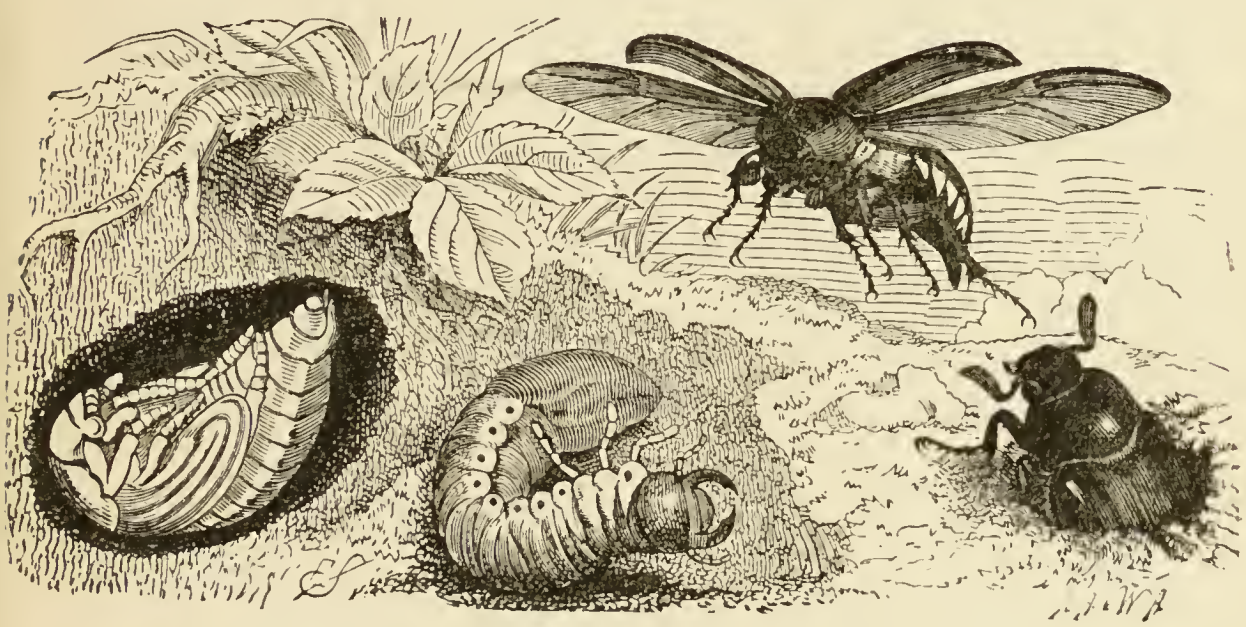

Fig. 65.—The Common Cockchafer (*Melolontha vulgaris*).
Larva, pupa, female flying, and male creeping out of the earth.

The time passed in the pupa state by insects with complete metamorphosis is by no means always of the same length. For example, there are two generations annually of the cabbage white butterfly; one lives through the winter in the pupa state, the pupæ of the other are found in summer. So that while an insect of the winter generation lives about half a year in the pupa state, this condition lasts only about a month in the summer generation. A higher temperature hastens the development.

Although the insect in the pupa state takes no

food, it nevertheless breathes, and therefore continually uses up body substance. This using up only takes place to a small extent however, since the animal moves but little. From whence, then, does the pupa get the material to cover the loss of body substance? In the larval condition the insect takes far more food than it requires for the development of its body, and from this excess it builds up reserve stuffs, which are deposited in the so-called "fat-bodies" of the larva. These reserve materials are re-absorbed during the pupa state, and serve to maintain the breathing. Consequently a pupa that has just been formed moves more than another one just about to become a butterfly.

FIG. 66.—Larva of a Weevil.

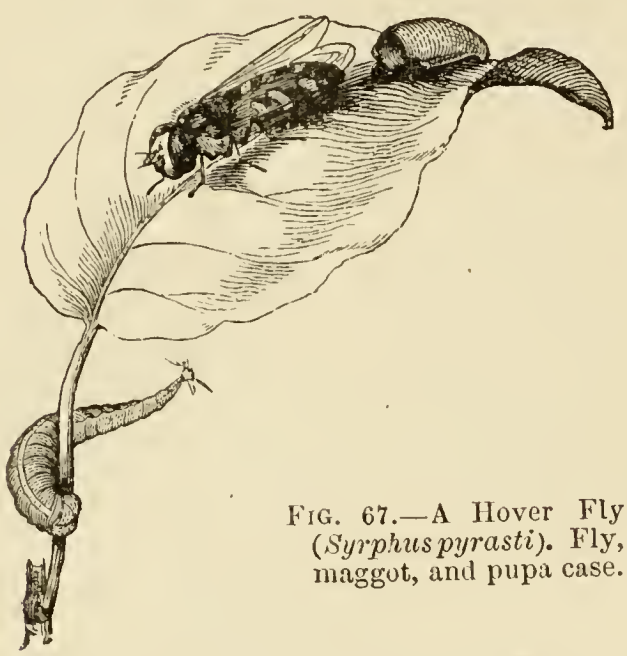

FIG. 67.—A Hover Fly (*Syrphus pyrasti*). Fly, maggot, and pupa case.

The larvæ and pupæ of the different kinds of insects which undergo a complete metamorphosis have not the same shape of body. Among the larvæ may be distinguished *caterpillars*, *grubs*, and *maggots*. The *caterpillars* (Fig. 60) have a clearly marked head with hard covering, three pairs of jointed thoracic legs, and a varying number of unjointed pro-legs. They are usually variegated or green in colour, and are divided into *true caterpillars* and *false caterpillars* (Figs. 60, 63, and 64). The first, after the resting pupa stage, become butterflies or moths; the latter sawflies. The true caterpillars have two to five pairs of pro-legs, the false caterpillars six to eight pairs. Reckoning in the thoracic legs, therefore, the true caterpillars have altogether five to eight, the false

caterpillars nine to eleven pairs. The head of the latter is more rounded, while that of the former is more flattened. The way in which caterpillars walk depends upon the number of their legs. If this is fairly large so that most of the segments of the body are provided with legs, the whole body remains tolerably extended during progression. But if the number is small—as in the looper caterpillars, where there are three pairs of thoracic legs at the anterior end, and at the posterior end only a terminal pair of legs (the caudal pro-legs) and another pair in front of them—the middle legless region is strongly bent during locomotion (Fig. 63). Hence the name "looper." The loopers often bend their bodies in a characteristic way. When at rest the hinder part is coiled up spirally; but as soon as the animals are alarmed they throw the hinder part of the body upwards and forwards and even over the head. The *grubs* (Figs. 66 and 69, *left*) have indeed, like the caterpillars, a clearly visible hard head, but no characteristic abdominal legs, or at most a pair of sucker feet at the end of the body (wireworms). Thoracic legs are present in several grubs (cockchafer larvæ, wireworms, leaf-beetles); in others (larvæ of weevils and fleas) they are entirely absent. *Maggots* are those entirely footless insect-larvæ which do not possess a head clearly marked off from the rest of the body, and the head-end of which is only to be recognized by the presence of the mouth and mouth-parts. *Pupæ* are enclosed in a case which either only faintly indicates the outline of the various parts of the adult insect, or else closely surrounds every part of the body—wings, legs, antennæ, and even the mouth-parts and eyes. Pupæ of the first kind are termed *obtectate* (Fig. 60); those of the second, *free* (Figs. 61, 65).

Many pupæ are *naked,* others are surrounded by a web (cocoon) spun by the larva (Fig. 60). There are

also pupæ distinguished by the peculiarity that when the insect has lived through the maggot-stage it does not strip off its integument, but turns into a pupa inside the shrivelled maggot-skin, from which the perfect insect later on breaks out (Fig. 67).

The class of insects can be divided into eleven orders: (1) *Coleoptera* (Beetles); (2) *Orthoptera* (Grasshoppers, Locusts); (3) *Neuroptera* (Dragon-flies); (4) *Hymenoptera* (Bees, Ants, Saw-flies); (5) *Lepidoptera* (Butterflies and Moths); (6) *Hemiptera* (Aphides, Bugs); (7) *Physopoda* (Thrips); (8) *Diptera* (Flies with two wings); (9) *Aphaniptera* (Fleas); (10) *Pediculina* (Lice); (11) *Collembola* (Spring-tails and Tassel-tails).

Order I.: **Coleoptera** (Beetles).

Beetles (Fig. 65) are insects with biting mouth-parts, and strongly developed prothorax united with the mesothorax so as to permit free movement. The fore-wings are in the form of hard covers, leaving exposed only the head, neck-shield (*i.e.* the dorsal side of the prothorax), a three-cornered bit of the mesothorax (*scutellum*), and sometimes the tip of the abdomen. Flight is effected by the hind wings alone, which in a state of rest are drawn back under the wing-covers. The metamorphosis is complete; the larvæ are legless, or with thoracic legs only, and have a hard head with biting mouth-parts; change into free pupæ (p. 93).

Family: **Carabidæ** (*Ground Beetles*).

Usually elongated, slender; with long slender legs, five-jointed tarsi, eleven-jointed antennæ, powerful jaws (Figs. 68, 69). Run rapidly; usually keep on the ground; hide themselves during the day, but are very active at night; with very few exceptions feed

entirely on other insects; when touched squirt an acrid stinking fluid out of the abdomen. Larvæ longish, six-legged, with short antennæ and sharp jaws, with a few exceptions live exclusively on other insects and lower animals.

Several species are of service, both in the adult and larval conditions, since they destroy injurious insects, *e.g.* surface caterpillars, wireworms, cockchafers,

Fig. 68 —A Ground Beetle (*Carabus auronitens*).

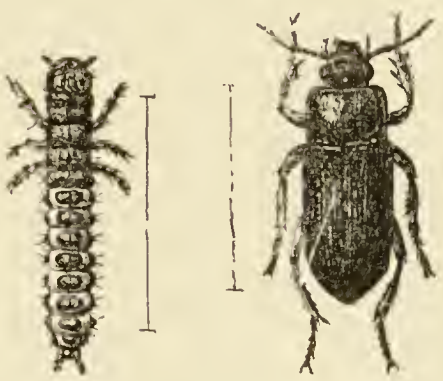

Fig. 69.—Corn Ground Beetle (*Zabrus gibbus*) and larva.

grubs, crane-fly larvæ. The following do good in cultivated fields: **Golden Ground Beetle** (*Carabus auratus*), **Garden Ground Beetle** (*C. hortensis*), **Granulated Ground Beetle** (*C. granulatus*), **Cross-barred Ground Beetle** (*C. cancellatus*), **Field Ground Beetle** (*C. nemoralis*), **Large-headed Ground Beetle** (*Cephalotes vulgaris*), species of *Harpalus*, *Pterostichus*, etc.

The only destructive form is the **Corn Ground Beetle** (*Zabrus gibbus*, Fig. 69); short, thick-set; back black; belly, legs, and antennæ dark brown. Larva cylindrical, slightly hairy, brown, with yellowish white belly; head broad and flattened, black. The beetles (June, July) usually remain hidden in the soil during the day, climbing up the stalks of barley, wheat, and rye during the evening and in dull weather, and eating the grain in the ear. The larvæ remain during the day in vertical holes which they dig out; but at night and during dull weather they devour the overground parts of the grain-plants

mentioned above, especially the hearts of young plants. They are destructive both in autumn and spring, damaging winter and summer grain. The larval condition is maintained for three years, the animal then turning into a pupa during July. Its ravages are limited to special years. *Remedy:* Sowing oats, peas, or vetches, or planting potatoes in fields infested by the beetles or their larvæ; collecting the beetles in the evening when they are in the ears.

Family: **Staphylinidæ** (*Rove Beetles*).

Usually elongated, small (Fig. 70). The short truncated wing-covers leave the whole of the abdomen exposed. The rove beetles resemble the earwigs in their appearance and in a way they have of fre-

FIG. 70.—Rove Beetle (*Staphylinus erythropterus*).

FIG. 71.—The Black Burying Beetle (*Silpha atrata*) and larva.

quently lifting up the hinder end of the body and turning it forwards. Tarsi five-jointed, jaws strongly developed. The six-legged larvæ resemble those of the ground beetles, but have a relatively large head. The beetles live through the winter; the metamorphosis takes place in autumn. Live on the ground under fallen leaves, also under the bark of trees; in carcases. Some chiefly eat insects living in the soil and noxious insects; others, dung and decomposing matter. (Species of *Staphylinus*, and of *Ocypus*, e.g. *O. olens*, the **Devil's Coach Horse**.) Several are of

service. A few devour the parts of plants. *Anthobium torquatum* is found in large numbers in the flowers of rape, devouring the petals, stamens, and pollen.

Family: **Silphidæ** (*Burying*, or *Sexton Beetles*).

The antennæ either thicken gradually or have only the end-joints larger; body flat; head projecting; tarsi five-jointed. The burying beetles and their larvæ feed on dead animals. A few (sp. of *Necrophorus*) bury the whole animal in the earth, and lay their eggs in it. Failing carrion, some of them can live on vegetable food; these sometimes do harm. Others prefer living insects and snails. They are of service in the economy of nature by doing away with stinking bodies. The following are sometimes harmful: **Black Burying Beetle** (*Silpha atrata*, Fig. 71), the larvæ of which often do much damage in fields of beetroot; *Silpha opaca* (**Beet Carrion Beetle**), and *S. reticulata*, which, in the adult condition, may do harm to several kinds of plants. Remedies need not be considered, as it is only rarely they increase so largely as to make the supply of carrion insufficient, and consequently attack plants.

Family: **Nitidulidæ** (*Shine Beetles*).

Small. Antennæ club-shaped, eleven-jointed. Tarsi five-jointed. A few species live on carrion and on fungi, others under the bark of trees, a few in flowers. To these last belongs the **Turnip Flower Beetle** (*Meligethes æneus*); somewhat convex, elongated oval; shining metallic greenish black, finely dotted. Occurs in the inflorescences of turnip, rape, and allied species; also in the flowers of mustard, charlock, and similar crucifers, and species of buttercup (*Ranunculus*). At the beginning of spring, the turnip-flower beetle bores into the buds of turnip, rape, etc., and, later on,

attacks the flowers. It perforates the petals, devours the stamens and pollen, and, lastly, the pistil. The infested flowers wither. Three to four beetles are often found in a single flower. The female soon lays her eggs, separately, in the ovary of the flower. One to two weeks later the larvæ may be found in the flowers, one or more in each. The larvæ, one-fiftieth of an inch long to begin with, are, when ready to become pupæ, about one-fifth of an inch long, cylindrical, yellowish white with blackish brown head; they have three pairs of short thoracic legs, as well as a pair of caudal pro-legs. Each segment of the body has two dark blotches on its upper side. On an average, the larvæ reach their full size in four to five weeks. They are first found at the bottom of the flower, where they gnaw the stamens and ovary. They then wander from flower to flower, until ready to become pupæ. If there are no more flowers in the neighbourhood they attack the developing pods, first gnaw the green husk, then bore through it and devour the young seeds. Become pupæ in the soil. The beetle emerges after a fourteen days' pupa-rest. At least two, usually three, sometimes four generations. *Remedy:* Rooting out charlock and the species of buttercup. Selection of strongly growing varieties of turnip, rape, etc., which blossom late (and therefore soon finish blooming). Drill-culture.

Family: **Cryptophagidæ** (*Secret-eating Beetles*).

Very minute. Antennæ composed of eleven joints, of which the three last form a club. Legs wide apart; tarsi five-jointed. Live in flowers, fungi, dead parts of plants, under bark, in the earth, in humblebees' and ants' nests, etc. The **Beet Beetle** (*Atomaria linearis*) is harmful: longish, egg-shaped, strongly convex; neck-shield as long as broad. Brownish black or dark brown. In fields where beet is cultivated

for several years in succession, the beetles often increase in a prodigious way. They attack the seedlings, and devour the base of the stalk just below the surface of the soil, sometimes biting it half through. The attacked seedlings often die even before the cotyledons appear above the surface of the soil. Looking, therefore, in spring at fields infested by the beet beetle, the seedlings will appear quite normally developed in some few places, while in some other places there may be no plants at all: in many spots, again, small plants will be seen bearing only seed-leaves, withered and yellow. These cannot be pulled out of the ground, for they break off at the place gnawed by the beetle. It is often necessary to give two or three successive sowings, as the young crop is attacked again and again. The larva of the beet beetle is still unknown, though this undoubtedly develops in the beet-fields. *Remedy:* Suitable rotation. When the conditions will not permit this, the seed must be sown thickly, so that as many seedlings as possible may remain sound, should the beetles exert their destructive influence in the spring.

Family: **Lamellicornia** (*Chafers*).

Body strong, stout (Fig. 65). The first joints of the antennæ have the usual shape; the last, three to seven, are very short, but broadened out on the inner side into leaf-like appendages, so that the end of the antennæ is fan-shaped (Fig. 72). The little leaves are laid together when at rest, so as to form a club-shaped thickened end; in flight, and when the attention of the beetle is excited, they are spread out like a fan. Legs strong; feet five-jointed. Flight rapid, somewhat awkward. Larvæ thick; body cylindrical, but

FIG. 72.—*a*, Antennæ of male; *b*, of femaleCockchafer.

curved; head hard, brown; rest of the body thin-skinned and yellowish white. The first three segments of the body bear legs. The curved larvæ can move about in the soil, but not on the surface. The beetles and larvæ devour vegetable substances; a comparatively small number of species feed on dung.

The **Common Cockchafer** (*Melolontha vulgaris*) will serve as a type of the lamellicorns (Fig. 65). The last segment of the body forms a gradually tapering process. The club of the antennæ with seven large leaflets in the male, and six smaller leaflets in the female (Fig. 72). Head, neck-shield, entire ventral surface, and legs, black; although these parts, with the exception of the head, may be reddish brown. Many specimens are thickly clothed with numerous white hairs; others are almost hairless. The beetles usually appear during May, but sometimes by mid April, and sometimes not till the beginning of June. In the evening they leave the soil and seek the neighbouring trees. They devour the leaves and especially the buds of oak, horse-chestnut, beech, poplar, willow, cherry, and other forest and fruit-trees, but spare the lime and generally the morel cherry. Of coniferous trees it only devours the needles of larch and the young shoots of pine. Among cabbage-like plants it only devours rape. In "chafer years" the cockchafer becomes a veritable scourge to the farmer. For the purpose of laying her eggs (about forty in number), the female selects by preference a fertile soil rich in humus, but will also put up with a dry sandy soil. The grubs devour the grass and clover-roots in meadows, and, in cultivated fields, the roots of grain-plants, peas, and beans, rape, cabbage, etc., also turnips and potatoes; in gardens the roots of many vegetables

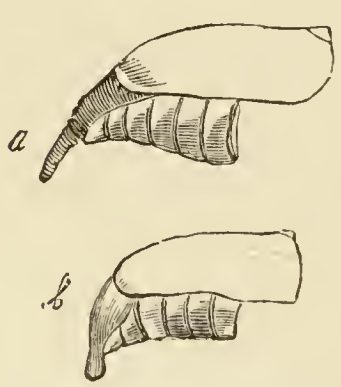

FIG. 73.—*a*, abdomen of Common; *b*, of Horse-chestnut Cockchafer.

and flowers, and, in particular, the underground parts of strawberry plants. If, on poor sandy soil, they can get nothing else, they devour the bark of oak and fir. Cockchafers take three to four years for their development: four in England, North Germany, and Central Germany; three in South France, Switzerland, the Rhine district, and Holland. In regions where the insect is abundant, every third or fourth year is a "chafer-year," when the beetles appear in millions, while scarcely a cockchafer can be found in the intervening years. In districts less infested there is not the same marked distinction. It therefore appears that cockchafers and their larvæ are to be reckoned as injurious insects: their occurrence, however, is local. *Natural enemies:* moles, shrews, bats, foxes, crow-like birds, starlings, sparrows, owls, and the large species of ground-beetle. Winter floods do no harm to the grubs, which are then deep in the ground,—but this is not the case with floods occurring in summer, when they are near the surface eating the roots of the plants. *Remedies:* Collecting the grubs turned up during ploughing. Catching the cockchafers; this is very expensive, since it has to be done very energetically if most of them have left the pupa-stage. A part of the expense may, however, be recouped by using the cockchafers as manure.

The **Horse-chestnut Cockchafer** (*Melolontha hippocastani*) has a short slender caudal process, somewhat broader at the tip (Fig. 73). Its habits are in no way different from those of the preceding species.

The **Buckwheat Beetle** (*Phyllopertha horticola*), one-third to one-fifth of an inch long, without a caudal process. Shining blackish green, with yellowish brown elytra. Dark-coloured specimens are also found. The beetles appear in June; in some years they occur, like cockchafers, in large numbers. Habits of the beetle and of the small grub not markedly different from those of the cockchafer.

The **Rye Chafer** (*Anisoplia fruticola*), somewhat larger than the buckwheat beetle, in other respects very like it, but with a snout-like projection of the thickened skin of the head. Dark bronzy green, whitish on the under side. Wing-covers yellowish brown. On poor sandy soil, on the flowering ears of rye. The beetles gnaw the flowers.

[The **Garden Chafer** (*Anisoplia horticola*) is closely related to the preceding. The grub is very harmful to pastures.]

Family: **Elateridæ** (*Click Beetles*).

The Click Beetles (Fig. 74) are longish, of equal breadth all along, tolerably blunt at the hind end. Neck-shield strongly developed. Antennæ "serrated," *i.e.* made up of three-cornered joints. Feet five-jointed. Looking at the under side a spine may be seen on the hinder margin of the pro-thorax (Fig. 75, *b*), and on the meso-thorax (*c*) a furrow which receives the spine when the body is extended, but the spine is drawn out of it if the pro-thorax and meso-thorax are lifted up from anything they happen to rest on (Fig. 75). A skipjack that has fallen upon its back first draws its antennæ and legs close to its body, and then bends this in such a way that the head and pro-thorax make an angle with the rest of the thorax

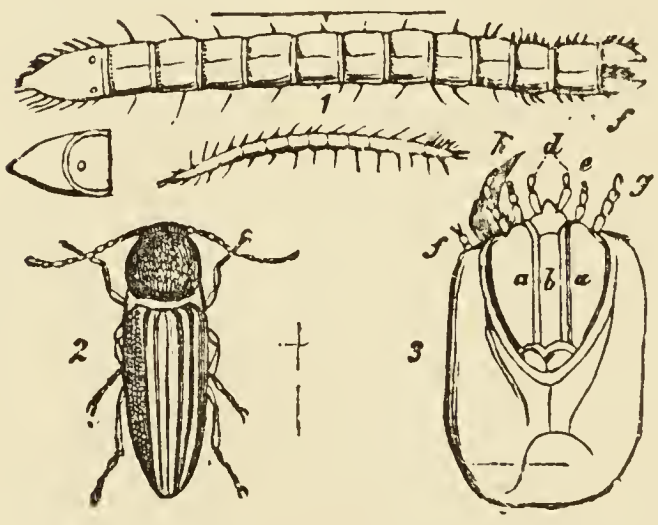

FIG. 74.—The Skipjack (*Agriotes lineatus*): 1, magnified larva, below it the under side of the tip of the abdomen and the larva, natural size; 2, the beetle; 3, under side of the head of the larva, strongly magnified. *a*, maxilla; *b*, lower lip; *d*, labial palp; *e*, *k*, inner and outer maxillary palps; *f*, antennæ.

and the abdomen. In this way the junction of the pro-thorax and meso-thorax is lifted up, and the spine drawn as far as possible out of the furrow. As soon as the beetle has taken up this attitude, it can spring back into its usual position by lifting the two ends of the body and pressing the spine forcibly back into the furrow, whereby it is jerked against the ground with such a shock that its elasticity makes it spring into the air, where it turns round and comes down again ventral side below. The larvæ ("wire-worms," Fig. 74, 1) are like meal-worms, elongated, always flattened on the ventral side, and sometimes on the dorsal side as well. The head is dark brown, the twelve remaining segments of the body yellow to yellowish brown; the first three segments of the body bear three pairs of very small legs; the last segment has a pair of caudal pro-legs.

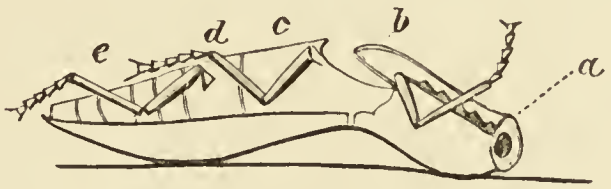

Fig. 75.—A Skipjack lying on its back and about to spring up. *a*, head; *b*, spine of the pro-thorax; *c*, meso-thorax; *d*, meta-thorax; *e*, abdomen.

Many species of click beetle are quite harmless, since they only devour decaying vegetable matter, either in humus or in the rotting substance of dying trees. There are also species, however, the larvæ of which feed on the living roots of plants. The wire-worms of *Lacon murinus*, which are tolerably thick and have a flattened tip to the abdomen, devour the roots of fruit-trees, rose-bushes, various vegetables (lettuce, cabbage, onions, turnips) and flowers; they are principally to be found in garden soils rich in humus. The relatively small hairless wireworms which do great damage, especially to grain-plants, but also to potatoes, carrots, turnips, rape, hops, and almost all the plants of our arable land, belong to *Agriotes lineatus* or *A. obscurus;* the larger and more hairy wireworms destructive in cultivated land

almost all belong to *Athous hæmorrhoidalis* or a related species. The species named above also do

FIG. 76.—Grain-plants sown deep and shallow; a wireworm is devouring the underground part of the stem of the first.

much damage in meadows and grass land. Those fields are most infested which bore grass or clover the preceding year. Wireworms are usually more destructive in dry soil than in wet. They devour all underground parts, but specially prefer fleshy organs (potatoes, turnips), as well as the underground stem-parts of grain-plants, working themselves up from the soil into the inside of the lower part of the haulm, where they destroy the plant by gnawing its base. They also often destroy, in young grain-plants, the region of the stem which extends from the remains of the seed to the surface (Fig. 76, *left*). In both cases the plant is killed by the wireworms; the injuring of the roots is less fatal. It is obvious that in shallow sowing only a small piece of underground stem is exposed to the attacks of wireworms, in deep sowing a much larger piece; besides this, a plant which has been sown shallow develops earlier a strong mass of roots, and in its young state can therefore offer a greater resistance to the destructive influence. Since wireworms require four or five years for their development, the same field is infested by them the whole year. The greatest damage is done in spring and autumn. When wireworms have gnawed into the lower part of the haulm, the lower leaves first turn yellow, and the death of the whole plant soon follows. *Remedies:* Repeated ploughing of fields infested by wireworms, so that rooks, starlings, wagtails, gulls, etc., can devour them. Perhaps, too, many larvæ are frozen. Sowing the seed as shallow as possible on infested fields (Fig. 76). Waste potatoes may be used as a means of drawing them from the crop.

Family: **Curculionidæ** (*Weevils*).

Most species are small. Head lengthened into a proboscis (Fig. 79, 3); the jaws are found at the front end of the proboscis, the eyes at its base. The antennæ,

which in most species are bent like a knee, and are always thickened at the tip, are attached to the front end, middle, or hinder end of the proboscis. The wing-covers usually extend to the tip of the abdomen, and clasp it in several species. Feet four-jointed. Weevils are mostly sluggish; many kinds do not fly at all; others only during the breeding season. When disturbed they let themselves fall to the ground as if dead. Almost without exception the females lay their eggs within plants, boring a hole by means of their proboscis, and shoving in the egg. The whitish larvæ (Fig. 66) are more or less curved and limbless, with hard brownish heads.

The **Seed Beetles** (*Bruchus*) have a very short snout. Body short, thick-set, almost four-cornered. The wing-covers leave the hinder part of the body exposed. The female lays her eggs in the seeds of leguminous plants. The larva hollows out one or several, becoming a pupa in the one last inhabited. Here belong the **Pea Beetle** (*B. pisi*), the two **Bean Beetles** (*B. rufimanus*

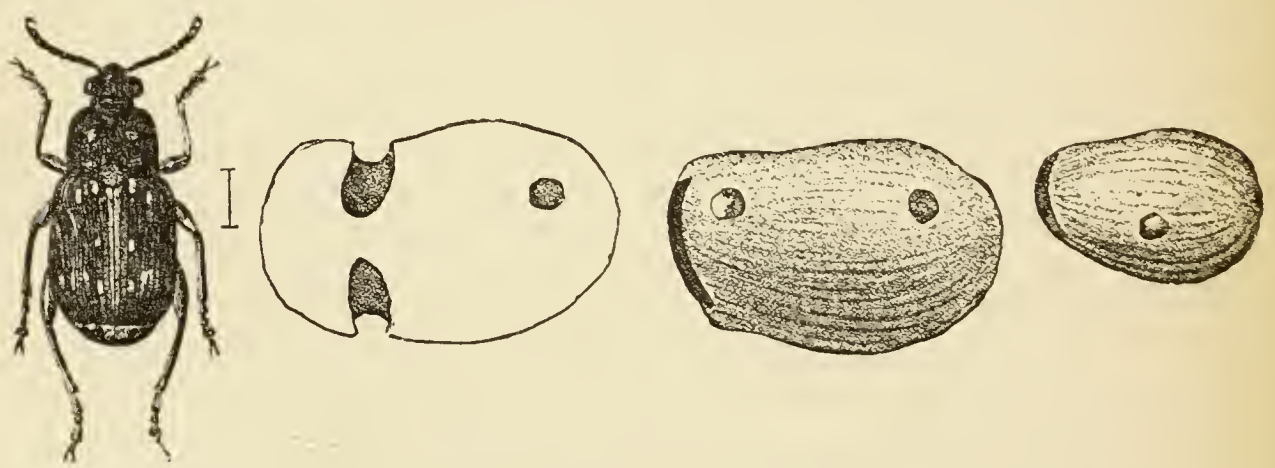

Fig. 77.—The Bean Beetle (*Bruchus rufimanus*) and beans gnawed by it.

and *B. granarius*), of which the last-named also lives in vetches and chickling peas, and the **Lentil Beetle** (*B. lentis*). The **Pea Beetle** (*B. pisi*) is black, with brown hairy covering flecked with white. Like all other species of seed beetle, it becomes a pupa in the last seed inhabited by the larva, and the pupa changes

into a beetle in autumn. A pea inhabited by such an insect can be recognized by a black translucent patch, since the beetle has become a pupa immediately under the seed-coat. Late the following spring the beetle crawls out. As the beetles are usually still in the peas at the time of sowing, the process brings them into the fields. Later on, when the beetles crawl out, they lay their eggs in the ovaries of the flowers of the pea-plants, which have meanwhile developed. The *remedies* are, consequently,—late sowing of the peas, or killing the beetles in them by exposure (for two minutes) to a temperature of 122° Fahr., or for ten minutes to sulphur dioxide fumes in a closed space. The remaining three species of Bruchus have the same habits as the bean beetle, but the insect often creeps out much earlier, so that the seeds do not require treatment.

The **Pea Weevil** (*Sitones lineatus*). Longish, with grey scales on a black background. Neck-shield

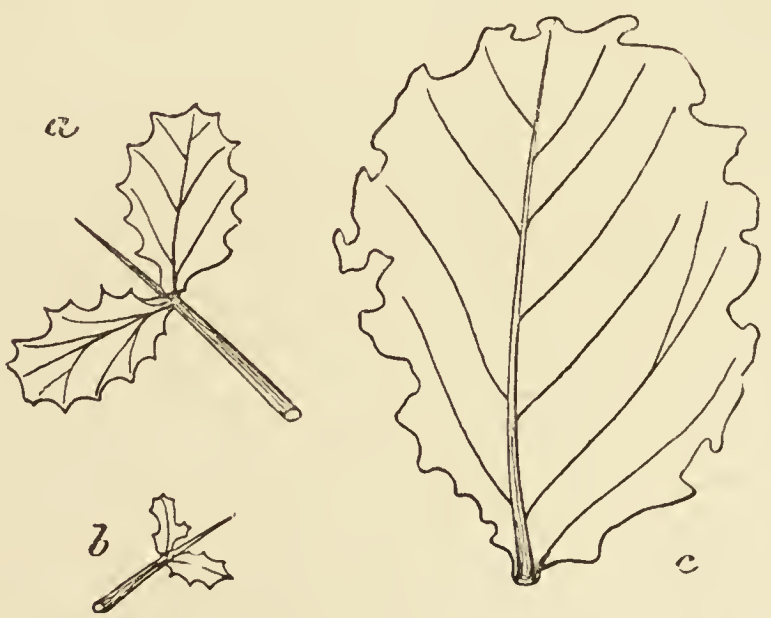

Fig. 78.—Attacks of Pea Weevil : *a*, *b*, on pea leaves ; *c*, on a bean leaflet.

with three longitudinal streaks, wing-covers with dotted lines. These weevils appear at the first beginning of spring on peas, field and garden beans, clover, and vetches. They gnaw the leaf-margins of

the tender plants, and always in such a way as to present a toothed appearance (Fig. 78). It often happens that in a large field one can scarcely find a pea-leaf with uninjured margin. When the plants are somewhat grown the damage done by the weevils is of no further importance; but if the plants, when still very young, are prevented from growing rapidly by reason of rough cold weather or unfavourable conditions of soil, while at the same time the weevils continue their attacks, the small leaves will be completely destroyed, and the plants will perish. The larvæ gnaw the roots of the plants infested by the weevils. *Remedy:* rational rotation.

The **Mouse-tooth Weevils** (*Baris*, or *Baridius*). Small, tolerably elongated weevils with fairly long neck-shield (Fig. 79). Develop in cruciferous plants. The **Rape Mouse-tooth Weevil** (*B. chloris*). Shining green. Leaves in spring its hiding-place in the soil; the female then lays her eggs in the leaf-axils or stem of rape or turnip. The larva eats out passages in the stem and branches; in July it becomes a pupa in the inside of the stem; in late summer the beetle appears, and quickly creeps into the soil. *Remedy:* Pulling up and burning the rape and turnip stubble, which harbours the weevil. The **Pitchy Mouse-tooth Weevil** (*B. picina*), one-sixth of an inch long, shining black. Similar habits to the previous species; but lives exclusively in headed cabbage and cauliflower, never in rape and turnip. The **Cress Mouse-tooth Weevil** (*B. lepidii*), black with blue or greenish-blue back, one-eighth of an inch long. Lives in the stems of cauliflower and garden cress.

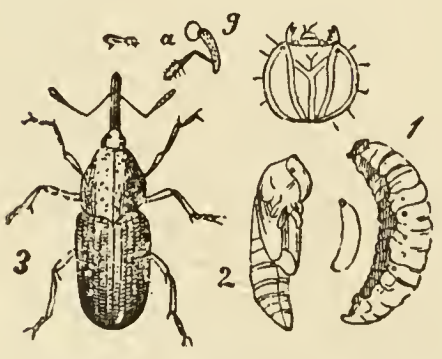

FIG. 79. — Mouse-tooth Weevil (*Baridius chloris*). 1, *larva;* drawn on the left, natural size, —above, the magnified head: 2, *pupa*, magnified: 3, *beetle;* drawn of the natural size above: *a*, eye; 1 *g*, antennary groove with antenna not drawn back.

The **Gall Weevils** (*Ceutorhynchus*) are very small

beetles with thick-set bodies. In a state of rest the proboscis is folded back into a ventral furrow, situated between the fore-hips. They are black, and thickly covered with grey hairs. Live on cruciferous plants. The **Turnip Gall Weevil** (*Ceutorhynchus sulcicollis*), one-eighth of an inch long, dull black, with many grey hairs on the ventral side and few on the dorsal side. The deeply pitted neck-shield has in its centre a well-marked longitudinal furrow. Wing-covers deeply furrowed. The beetle appears in April, and gnaws the flowers and shoots, but can scarcely be considered as harmful. In late summer or autumn, after the sprouting of the winter rape, the female bites into the root immediately under the surface of the soil, or into the lower parts of the stem, so as to form a hole in which she lays one or two eggs. As the larva begins to develop, the surrounding parts of the stem or root grow into a gall-like swelling (Fig. 80). At the beginning of spring the developed larvæ creep out, and become pupæ in the soil; in April the beetle appears. If the Ceutorhynchus galls are only present in small numbers they damage the rape plants only to a small extent, but when ten to twelve are found in one plant the roots grow crooked, and remain short, and consequently the growth of the overground parts is detrimentally affected. Ceutorhynchus galls are

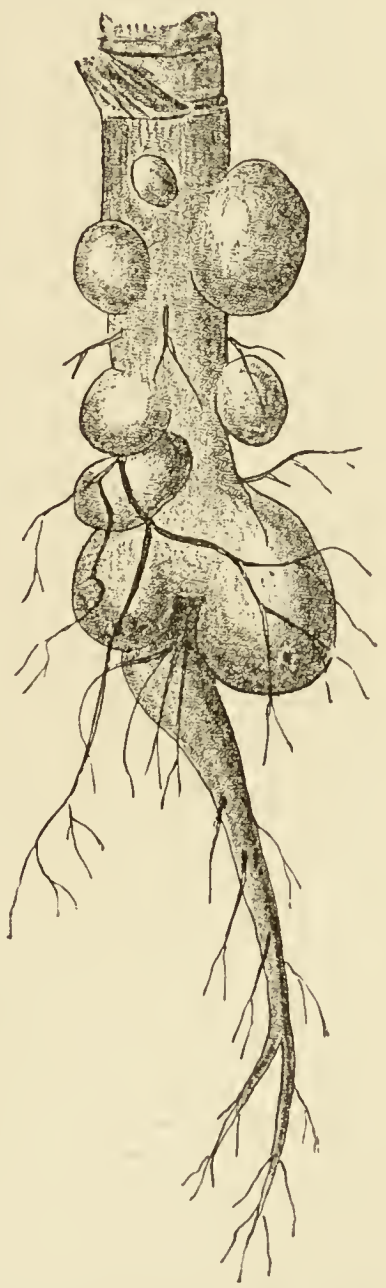

Fig. 80.—Turnip Gall Weevil (*Ceutorhynchus sulcicollis*).

found, not only on rape, but also on the different kinds of cabbage, and on turnip plants. In the last case they often occur in such numbers that the turnips do not develop at all, and the overground parts also remain small. There is a similar form (*C. assimilis*), as large as the preceding species, but somewhat slimmer, and, on account of greater hairiness, greyer. Appears in spring on flowering rape and several kinds of cabbage, as well as on similar cruciferous plants. It is harmful because the beetles gnaw the buds and flowers, and the larvæ feed on the seeds within the pods. The attacked pods ripen early, and open so that the larvæ fall to the ground, where they become pupæ. Usually only a single larva is found in each pod. The **Rape Gall Weevil** (*C. napi*), somewhat larger than the two preceding species, has a neck-shield which projects strongly forward like a collar, and is marked by a median longitudinal furrow. It is covered with yellowish-grey hairs. At the time when rape blooms it appears upon the flowers. The female lays her eggs singly in a hole previously bored in the stalk by her proboscis; during spring and early summer the larva eats out the stem, which turns brown inside, and becomes diseased or even dies.

Family: **Chrysomelidæ** (*Leaf Beetles*).

Small, generally thick-set beetles, arched on the upper side, with eleven-jointed antennæ thickening somewhat towards their tips, and four-jointed feet. The first joints of the feet are covered with felt-like hairs on their under sides (Fig. 81). The larvæ have three pairs of thoracic feet, and, in addition to this, there are in most species a pair of caudal pro-legs. Live in the inside parts of plants (stems, leaves), and are usually elongated and yellowish white; those which live on the outside of plants are more convex, shorter, and thicker, more or less hairy, often of a

striking colour, and always with dark spots. The beetles eat leaves; the larvæ feed upon parts of the same plants, sometimes living outside upon the leaves, or it may be excavating channels in the inside of a leaf or of the stem. Most leaf beetles lay many eggs, and in many species there are several generations annually. The plants attacked by them are often stripped quite bare. Here belongs the blue **Alder Leaf Beetle** (*Galeruca alni*), the **Poplar Beetles** (*Chrysomeli populi* and *C. tremulæ*), the **Asparagus Beetles** (*Crioceris merdigera* and *C. duodecimpunctata*), etc. Of species injurious agriculturally, I will first mention the **Colorado** or **Potato Beetle** (*Chrysomela decemlineata*). This beetle originally lived in the west of the United States on wild solanaceous plants; but as soon as potato culture extended to the west the beetles also attacked potato plants. As soon as the insects had spread to this plant they began to appear in great numbers owing to their very great powers of reproduction; and they quickly spread from one field to another, always going further and further east. 1859 was the first year when they became notorious as pests, and, since they first appeared as such in the State of Colorado, the insect received the name "Colorado Beetle." In a short time the beetles spread to the east, especially to places where potato culture was carried on; in 1865 they crossed the Mississippi, and in 1870 they were already spread over the states of Indiana, Ohio, Pennsylvania, Massachusetts, and New York. They were soon found in all the eastern states, and European farmers began to be alarmed. In most of the countries of Europe police regulations were made for the purpose of preventing the introduction of the unbidden guests. Colorado beetles have indeed been brought several times to

FIG. 81.—Potato Beetle (*Chrysomela decemlineata*).

Germany on board ship, but in almost all cases the pests so introduced have been recognized and caught. Twice during 1877 they were able to increase (Mulheim, Schildau), and the same thing has happened once at a more recent date (Torgau); but the vigorous action of the authorities quickly exterminated the beetles.

Beetle (Fig. 81), half an inch long, dusky yellow, with five longitudinal black streaks on each wing-cover, and black markings on the neck-shield. Larva (Fig. 82), half an inch long, thick, fleshy; legs short

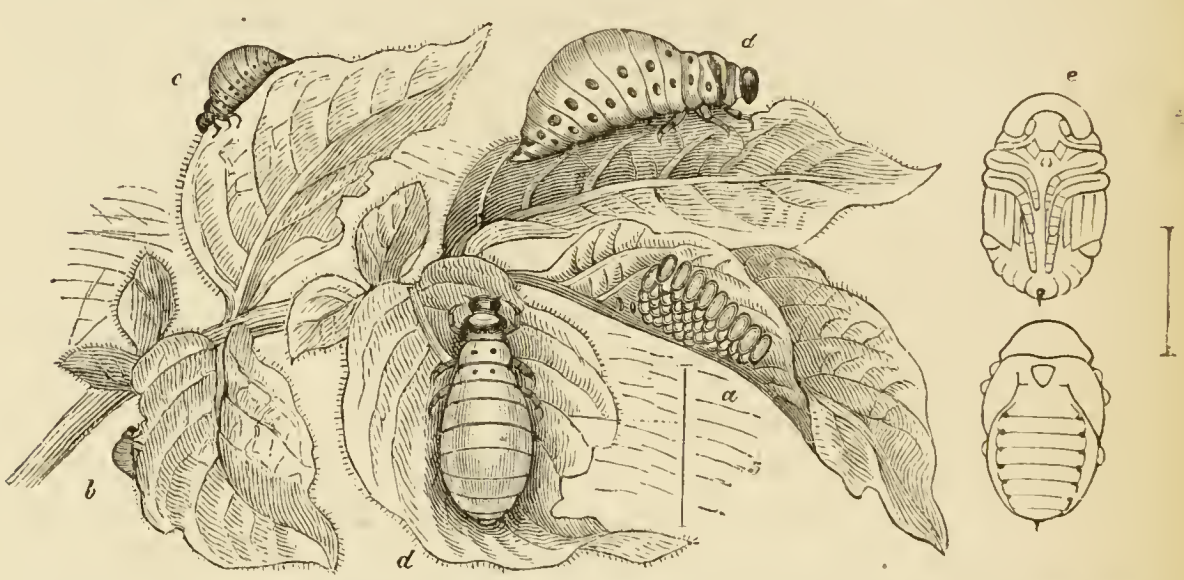

FIG. 82.—Colorado Beetles: *a*, eggs; *b*, *c*, *d*, younger and older larvæ; *e*, pupæ seen from the ventral side and from the dorsal side.

and weak. Orange-yellow, with shining black head, and with black spots on the body segments. The younger larvæ are darker, almost blood red. When the young potato plants come up, the beetles which have survived the winter creep out of the soil and devour the margins of the young leaves. The female lays her yellow eggs (700 to 1200 ?) in heaps on the leaves (Fig. 82, *a*). After a week the larvæ appear, and carry on the work of the beetles. They attain their full development in seventeen to twenty days, become pupæ in the soil, and the beetles of the second generation make their appearance in the middle of June. Still a third generation may appear the same

year. Since a considerable time elapses between the laying of the first and second batches of eggs, one usually sees eggs, larvæ, pupæ, and beetles at the same time. Entire potato fields are eaten bare by the beetles and their larvæ, the formation of the potatoes being quite prevented. *Remedies:* Energetic measures must be taken on the first appearance of the beetle in any district. Where possible, all the beetles and larvæ must be collected, the plants being dug up and destroyed with the beetles, pupæ, larvæ, and eggs adhering to them. Petroleum must then be poured over the whole field and set on fire, so as to destroy any insects which may be hidden in the soil. Spraying the attacked plants with Schweinfurt green.

The **Cloudy Tortoise Beetle** (*Cassida nebulosa*)—Fig. 83. One-fifth to one-fourth of an inch long; the broad neck-shield projects in front over the small head. The wing-covers, too, are much broader than the body of the animal; they are longitudinally ribbed. Dorsal side reddish-brown, in young individuals greenish; always with black spots. Ventral side black. Larva elongated oval, yellowish green. Segments of the body beset with thorn-like structures bearing lateral branches; the last segment possesses a "tail-fork," which the larva usually carries bent over its back and on which it heaps up its dung. The beetles which have survived the winter usually attack in spring only wild goose-foot and orach plants, on which they lay their eggs in heaps. The larvæ quickly appear, and to begin with chiefly keep to the under sides of the leaves. They are sluggish, grow quickly, and devour the leaf substance; when fully developed they cement themselves to a leaf and become pupæ. In June the beetles of the second generation appear, which again lay their eggs on the

FIG. 83.—The Cloudy Tortoise Beetle (*Cassida nebulosa*).

leaves. In favourable weather there may be even a third generation. In many it happens that the beetles of the second generation migrate to beet or mangold plants, sometimes damaging them to a very great extent. *Remedy:* Rooting out species of goose-foot or orach.

The **Earth Fleas,** or **Flea Beetles,** are all small leaf beetles with the power of springing, and therefore provided with thick thighs. Here belong:—

The **Rape Flea Beetle** (*Psylliodes chrysocephalus*)—Fig. 84. Egg-shaped. Hind feet not inserted at the ends of the shanks, but higher up. The first joint of the foot is as long as the others put together. The rest of the hind foot is bent in a knee-like way on the first long joint. Shining blackish brown or blackish green, rarely brownish. Larva one-fifth to one-fourth of an inch, dusky white; head, neck-shield, and last segment of the body blackish brown. In spring and during the entire summer the beetles are found upon the plants of winter rape. Although they gnaw the leaves and the immature shoot the damage caused is small. In late summer or autumn the female beetles lay their eggs separately at the bases of the leaf-stalks of the young winter rape plants. The larvæ which emerge bore into the leaf-stalk, and eat it completely out during autumn, winter, and spring, so that the leaf dies. Since the eggs are laid separately the larvæ do not all develop at the same time in the spring. In spring many larvæ eat their way from the leaf-stalks into the still very short stem, which consequently ceases to develop. It often happens that

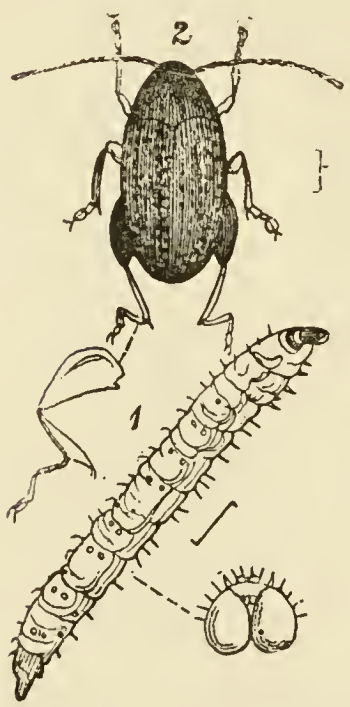

Fig. 84.—The Rape Flea Beetle (2) with hind-leg of the same; larva (1) and its head.

most, or even all, of the plants in a rape field are withered; on poor soil the whole crop must be at once ploughed up; but on fertile soil the plants often develop much better than one would believe. Plants whose stem has been killed in the winter while still short may develop a few (3 to 5) branches from buds situated near its base, but these usually remain small, and do not yield a large crop. The beetles, appearing in spring, lay their eggs on the lower leaf-stalks of the rape, either on the old plants of winter rape or young plants of summer rape. In the latter case the summer rape is quite spoilt in the same way as the winter rape during the previous winter. In the former case the larvæ eat out the lower part of the leaf-stalks, and make their way into the stem, hollowing it out at a definite spot in such a way that it is no longer able to hold itself up, especially when the shoots and seeds develop. The stems bend and become kneed, sometimes to such an extent that the rape-field looks as if persons or cattle had been running about in it in all directions, and treading everything down. Meanwhile the larvæ bore their way out of the stem, and become pupæ in the soil. In late summer the beetles appear, and once more lay their eggs on the leaf-stalks of the winter rape. There are, therefore, two generations annually. *Remedies:* Never sow summer rape after winter rape which has been destroyed by the beetle and ploughed up. Temporary limitation of rape culture.

The **Cabbage Flea Beetle** (*Haltica oleracea*), one-fifth to one-sixth of an inch long, longish oval, dark green, metallic sheen. The hind legs do not possess the peculiar features of the rape flea beetle (p. 114). Larva one-fifth to one-fourth of an inch long, greyish black, with bristly hairs, and with two rows of shining black warts. The beetles attack, in the spring, chiefly cabbage, rape, radishes, horseradish; but do not spare other plants (*e.g.* peas and beets) as well. Seedlings

are chiefly attacked, and in all cases only young plants are devoured. Since both seed-leaves and terminal buds are eaten, much damage is done, especially during continuously dry weather. It must often happen that the beetles wander away, to find other species of plants for the purpose of egg-laying; so that it is exceptional to find the larvæ upon species of cabbage. These larvæ are much less injurious than the beetles, since they usually only prey upon mature plants. In their youngest condition they are found in groups, feeding upon the leaves; this results from the eggs being laid in little heaps. Later on, they wander away from one another. In favourable weather they are fully grown in six weeks, and several generations may succeed one another in the same year. *Remedies:* Destruction of the weeds which attract the beetles (charlock, shepherd's purse, yellow rocket, treacle mustard, etc.) Good preparation of the soil, suitable manuring and drill culture, since these bring about a more rapid growth of the plants. Thick sowing (but not too thick), so that, even after the destruction of many seedlings, a sufficient number may remain. Moistening the fields by means of water-carts or sprayers. In garden-beds twigs are laid down, by which the seeds are protected against birds and the seedlings against flea beetles. "Flea-beetle machines," consisting of a board smeared with tar, which is drawn across the field, so that the frightened beetles spring up, and remain hanging in the sticky substance. After rain, or when dew is still clinging to the plants, they should be strewed with powdered fowls' dung, pigeons' dung, or horse dung, wood-ashes, road-dust, powdered lime, coal-ashes; or the plan of sprinkling with a decoction of wormwood may be adopted.

The **Turnip Flea Beetle**, or **Turnip Fly** (*Haltica nemorum*), one-tenth to one-eighth of an inch long, egg-shaped, black, with longitudinal streaks of a

sulphur yellow colour on the thickly pitted wing-covers. Larva one-fifth of an inch long, yellowish white, with dark brown head, neck-shield, and last body-segment. The adult beetles have the same habits as in the preceding species; they also do damage in the same way, and attack the same plants, especially in the seedling condition. The female, however, does not lay her eggs in heaps, but separately on the leaves, and always on the under side. The larva bores into the leaf, and digs a passage, which, like the animal inhabiting it, is at first small, but gets gradually larger. In fine weather the larva is fully developed in a week. It then pierces the skin covering the under side of the leaf, falls to the ground, and becomes a pupa. Several generations may appear every year, if the weather is favourable (dry). This species is quite as harmful as the preceding, chiefly in the mature condition. *Remedies:* Compare the preceding species.

Family: **Coccinellidæ** (*Lady-birds*).

Hemispherical; upper side convex; under side flattened. Head small, retractile. Antennæ, eleven-jointed, thickened at their tips. Legs short; feet apparently three-jointed—in reality four-jointed, the second joint, however, being very small. Colour, usually variegated; many species black with red, or red with black spots. When grasped, they let a yellowish, unpleasant-smelling fluid escape from the abdomen. The blunt, four-cornered, usually variegated pupæ hang on the leaves. The fully developed larvæ are longer than the beetles. They closely resemble those of the leaf beetles, but are not so thick-set, and their longer legs stick out more laterally. They are covered with warts and little spines (Fig. 85). The larvæ and beetles of most species feed chiefly on aphides and shield-lice; they are therefore of use, and this is especially true of the exceedingly

ravenous larvæ. The larvæ of the Seven-spotted and Two-spotted Lady-birds, in particular (*Coccinella*

Fig. 85.—The Seven-spotted Lady-bird (*Coccinella septempunctata*): larvæ, pupæ, beetles; all natural size.

septempunctata and *C. bipunctata*), are found in large numbers among aphis colonies. The yellow eggs are laid in heaps.

Second Order: **Orthoptera** (Straight-winged Insects).

Insects with biting mouth parts and incomplete metamorphosis (p. 89). Four wings, of which the anterior are usually harder than the posterior; hind wings membranous, broader than the fore wings, and folded like a fan. The Orthoptera feed entirely, or almost so, upon vegetable substances. To this order belong:—the **Earwigs** (*Forficulariæ*), which feed on sweet fruits and flowers, and are sometimes very injurious; the **Cockroaches** (*Blattariæ*), which do much damage to provisions in kitchens, stores, and on board ship; the **Grasshoppers** (*Acrydites*), to which, besides the **Migratory Grasshopper** (*Acrydium migratorium* (Fig. 62), various species of meadow grasshoppers belong, which are quite harmless; the **Locusts** (*Locustidæ*), to which the well-known **Green Locust** (*Locusta viridissima*) belongs; and the **Crickets** (*Gryllidæ*), to which belong, among others, the **House Cricket** (*Gryllus domesticus*), the quite harmless **Field Cricket** (*Gryllus campestris*), and the **Mole Cricket** (*Gryllotalpa vulgaris*).

The **Migratory Grasshopper** (*Acrydium migratorium*).

$1\frac{3}{5}$ to $2\frac{3}{5}$ inches long; spread of the wing, on the average, $2\frac{1}{2}$ inches. Greenish grey. Under side flesh colour. Wing covers brownish, darkly flecked. Colour very variable (Fig. 62). Excessive multiplication and migrations of this insect often take place in South Russia and Turkey; but they may also appear in Central Europe. In North Germany, for example, the following years of this century were "grasshopper years:" 1803, 1825–27, 1853, 1875–76. In many cases the appearance of swarms of grasshoppers in Central Europe is due to migration from Russia and Hungary; but it also often happens that the insects which appear in such large numbers have been bred in the places where they are found. Since the female lays, on the average, 150 eggs, excessive increase may take place in any country to which they are indigenous—and therefore in Central Europe. It appears, however, that a large number of grasshoppers are usually killed by their natural enemies, such as cold and damp weather. Excessive increase may, however, take place in exceptionally favourable years; and since the larvæ, which are incapable of flight, devour everything available, the mature insects developed from them are forced to migrate. Where they descend they destroy everything they find in the fields. *Remedies:* Destruction of the longish eggs, which are laid in heaps in the earth of fallow ground and meadows. In all those places where dead insects are found in large numbers on the ground many eggs will also be discovered, for the insects keep on laying till they sink down dead in the place where the last heap of eggs was deposited. Such places should be dug or ploughed, and the eggs, which are present in thousands, either collected or else searched out by pigs, ducks, geese, and fowls, which have been driven to the spot. Destruction of the young animals while

still incapable of flight. Working the soil with harrows, rollers, and cultivators will be effective here. The adult grasshoppers must for the most part be destroyed with fire. [Heaps of straw and brushwood are soaked with paraffin and then set on fire.]

The **Mole Cricket** (*Gryllotalpa vulgaris*).

Body stout and flattened. Antennæ, palps, and tail-filaments very long. Fore legs broad, modified into true "digging legs," superficially resembling the feet of a mole. Fore wings broad, but short, leathery. In a state of rest, the hind wings lie on the back, like a couple of tails. Colour dark brown. Principally occurs on peaty soils mixed with sand or clay, also on all soils which have become of firm consistency by the application of much manure. Their presence is therefore local. Very early in the year the mole-cricket leaves its winter hiding-place, and begins to make its passages near the surface. Where the female makes her nest the passage turns downward a little. The nest is $1\frac{3}{5}$ of an inch in diameter, and its walls are compacted by the pressure of the hard body. The number of eggs is from 200 to 250; they are laid in lots with a few intermediate spaces. The young creep out in the spring, and are wingless. To begin with, they are white, but quickly become brown. The mother guards her young very carefully. These grow tolerably fast, and first begin to lead an independent life after the second moult. In October and November they undergo a third moult. Then, still in a wingless condition, they hide themselves, and do not moult again till April or May, when the wing-cases appear; while after the fifth moult (May, June) the mole cricket becomes an adult insect, capable of reproducing. This insect is found in cornfields, gardens, grassland, and meadows, also in orchards and woods. It gnaws the roots of all kinds of plants, and often effects great

damage in this way. The mole-cricket is also harmful on account of its passages, which are dug close to the surface. In this way it lifts young plants out of the soil; while older plants are killed, both by its gnawing and by its digging. Such plants can often be pulled up by grasping the leaves. All the plants wither in the place where the nest is found. Dry, cold winters kill almost all the mole-crickets; much drought in summer and also continuous wet are unfavourable to them. *Enemies:* moles, rooks, etc., butcher-birds, starlings, and the larger ground beetles. *Remedies:* Destruction of the nests, in June, to begin with, but also to be continued later. In those parts of a field where the plants are yellow or withered in a large circular patch (some 39 inches in diameter) the nest is felt for with the finger, and carefully lifted up, so that the eggs do not fall out. Mole-crickets can also be caught by means of flower-pots. The apertures in the bottoms of these are stopped with corks, and they are then sunk in the soil with their mouths on a level with the mole-cricket passages; they thus serve as pitfalls, from which the insects cannot escape. If during winter little heaps of horse-dung are placed on the ground, the insects creep into them for the sake of the warmth, and can thus be collected and killed.

Third Order: **Neuroptera** (Net-winged Insects).

Insects with biting mouth-parts and four similar membranous wings, with numerous veins arranged in a net-like manner. The metamorphosis is either incomplete (p. 89: dragon flies, may flies, book lice), or complete (p. 89: ant lions, lace flies, snake flies, scorpion flies, caddis flies). The indigenous forms, with the single exception of book lice, feed upon animal food, usually on the juices of other insects. Several of them are tolerably useful in this way.

The **Dragon Flies** (*Libellulidæ*) fly about incessantly from place to place on bright warm days, and catch a large number of insects, especially butterflies and flies, among which are many that are harmful. The larvæ live in water, and feed on insects and such small deer, which, however, are of no importance to forestry or agriculture. They also devour fish-spawn, and may therefore be injurious in that way.

The **Lace Flies** (*Hemerobidæ*) when at rest are covered as with a roof by their fore and hind wings, which are almost alike, clear as glass, and finely veined. Head tolerably large, eyes large, abdomen elongated and slender. The extremely rapacious larvæ (Fig. 86, *b*) feed on the juices of the bodies of other insects, which they suck up by means of a

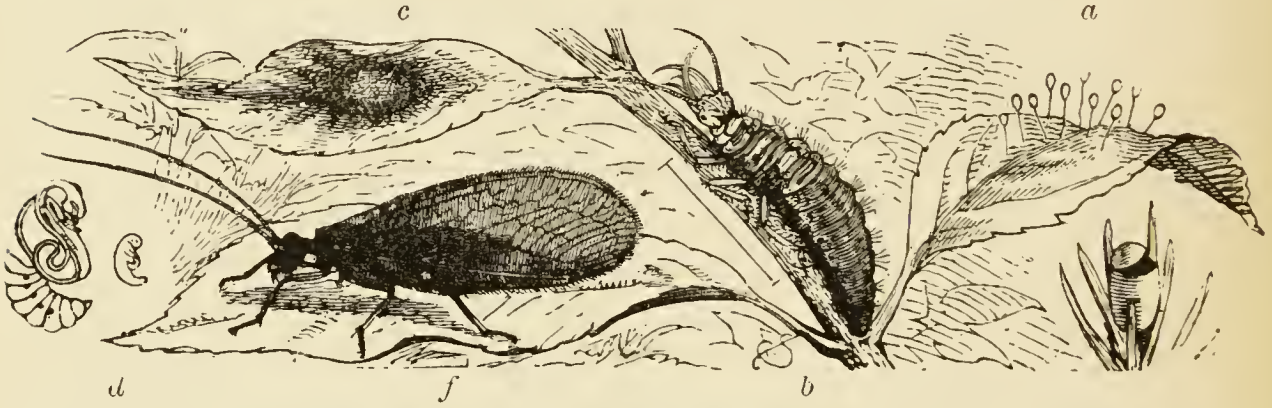

Fig. 86.—The Common Lace Fly (*Chrysopa vulgaris*): *a*, eggs; *b*, the larva; *c*, cocoon; *d*, pupa contained in the same; *e*, open cocoon; *f*, adult insect; *a*, *c*, *e*, natural size; *d*, enlarged and natural size; *b* and *f* enlarged.

pincer-like organ situated on either side of the mouth. The two pincers are perforated, and the tubes open on each side into the gullet; the body juices of the insects attacked thus flow into the gut of the larva. This is strongly built, and always much thicker and larger than the adult insect. Metamorphosis complete. Three genera belong to the lace flies:—

1. The delicate greenish, or greenish yellow, ill-smelling **Gold-eyed Lace Flies** (*Chrysopa*), the larvæ of which chiefly feed on plant lice (a few species on caterpillars, also, and other small insect larvæ).

2. The **Aphis Lions** (*Hemerobius: H. hirtus*, with

hairy veins on the fore wings; *H. dipterus*, with hind wings almost entirely absent), the larvæ of which also feed on aphides, and make a case from their sucked-out skins.

3. The **Ant Lions** (*Myrmeleon*), of which the fat, thickset larvæ, which have a large head and strong grasping pincers, dig out in the sand funnel-shaped holes, at the bottom of which they hide, lying in wait for ants and the like, which step on the edge, when the sand gives way and causes them to fall in. The species of the first two genera are of service as destroyers of aphides; the ant lions are of no importance.

The **Scorpion Flies** (*Panorpatæ*) have attached to the head a kind of proboscis, the upper side of which is formed by a prolongation of the forehead, and the under side by the maxillæ and lower lip, while the upper lip and mandibles are hinged on at its tip. Here belongs the slender-bodied **Scorpion Fly** (*Panorpa communis*), an insect found in May, and again in July or August, on the leaves of trees and shrubs, when it is sunny. While the abdomen of the female ends in an ovipositor, it bends upwards in the male, and terminates in a pincer-like organ; hence the name "scorpion fly." Wings flecked with brown. Scorpion flies catch on the wing a very large number of butterflies and moths, and are therefore useful to some extent.

Fourth Order: **Hymenoptera** (Membranous-winged Insects).

Upper lip and mandibles short; the latter used for biting. Maxillæ loose-jointed, so that they can be stretched out considerably; elongated in those which lick the juices of flowers. In the last-named forms the larva's lips are still more elongated, and may even form a tongue or proboscis-like organ, which may bear lateral appendages ("secondary tongues").

Wings, four, all membranous, with relatively few veins (Figs. 61, 90). Metamorphosis complete; larvæ very various; pupæ free (p. 93). The female usually possesses an ovipositor, the structure of which varies a great deal, and which serves in many species, not only for egg-laying, but also for protection (digging wasps); in others exclusively for offence or defence ("stings" of bees and wasps), while the same opening serves for the passage both of eggs and excrement. The abdominal glands, secreting a sticky substance by which the eggs are attached, are modified into poison-glands in those Hymenoptera which possess a sting. In those forms where the ovipositor is not modified into a sting, it is used for piercing, biting, or sawing. The Hymenoptera with saw-like ovipositor first make an opening in wood or in a leaf by means of the saw-teeth in its edge, and then lay an egg in this hole.

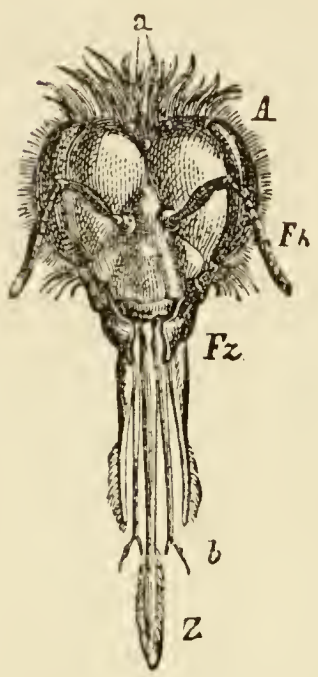

FIG. 87.—Head of Honey Bee. *A*, compound eyes; *a*, simple eyes; *Fh*, antennæ; Z, tongue (under lip); *b*, labial palps; *Fz*, elongated maxillæ; the mandibles and upper lip remain short.

Many Hymenoptera (all digging wasps, gold wasps, ichneumon flies, and gall flies—several true bees and wasps) live alone, or in pairs. Others form colonies, in which division of labour is always so far carried out that there are *reproductive individuals* and *workers*. The former (males and females; in colonies of bees—"drones" and "queen") are only present in small numbers in any particular colony. They live merely for the perpetuation of the species. At most the males seek their own food, while the females are usually fed by the workers. Workers, on the other hand, are individuals in which the (female) reproductive organs remain in a low state of development, so that they are sterile. They seek food for the

larvæ, and usually for the adult reproductive individuals as well. They also wage war against strange intruders.

Family: **Apidæ** (*Bees*).

The bees, by means of their very much elongated mouth-parts (maxillæ and lower lip or "tongue"), collect honey from many different kinds of flowers. Body somewhat unwieldy, usually hairy. The fore wings are not, as in wasps, folded together longitudinally when in a state of rest. Eyes round. The legless, almost maggot-like larvæ are fed with pollen or with a mixture of pollen and honey.

Most bees are colonial, and in these we find, besides the reproductive individuals, workers which prepare the nest. This is for the most part made up of "cells," in the construction of which the most various substances are used according to the species, *e.g.* wax, sand grains, chewed wood, fragments of leaf. In each nest there is at the same time only *one* queen, who lays her eggs in the cells; the larvæ are therefore developed in these cells, other cells serve for the storage of pollen or honey. In the non-colonial bees there are no workers; in a few of these species (parasitic bees, cuckoo bees) the female lays her eggs in the cells of other species, which, like foster parents, undertake the care of the strange larvæ. These species are naturally devoid of the apparatus for securing and carrying pollen. In several bees (honey bees, humblebees) this end is attained by the much-broadened shanks and first, very large foot-joints of the hind legs. Other bees (*Megachile*) carry pollen on the under side of the abdomen.

Bees play a very important part in the pollination (fertilization) of many cultivated plants.

The **Honey Bee** (*Apis mellifica*) cannot be spoken of here; reference must be made to works on apiculture.

The **Humblebees** (*Bombus*) are tolerably large, stout, thick-set, and hairy. They construct nests below the surface of the soil (often in peaty places), made up of oval or irregular waxen cells the size of a hazel-nut. They fly rapidly, always making a humming sound. Many species are black, with yellow and white, or red transverse stripes.

Honey-producing flowers in which the corolla is so long that even the proboscis of humblebees cannot reach the honey hidden at the bottom of the flower, (tobacco, field and garden beans) are gnawed at their base by the sharp mandibles of the bees, so that a hole is made in the calyx and corolla through which the tongue can be put. In this way the ovary is sometimes wounded, and the normal development of the fruit rendered impossible. Perhaps a certain amount of damage, always however inconsiderable, may thus be effected.

Family: **Vespidæ** (*Wasps*).

Mouth-parts as in bees. Also with stings. Slender, and either hairless or only slightly hairy. Eyes kidney shaped. Fore wings folded together longitudinally when at rest (Figs. 61 and 88).

A distinction is made between solitary and social wasps; the latter possess males, females, and workers. Only the fertilized queens survive the winter. In the spring each of these begins to construct a nest (Fig. 88). In the wasp's nest each comb consists only of a single layer of cells, the openings of which are turned downwards. In a single nest several of these horizontally placed combs are usually found one over another, and are connected together by means of vertical pillars. Some nests are built in hollow trees, others in holes in the ground; others hang freely from trees, in which case they are covered by several layers of a papery substance. The combs and cells are also made of paper, to prepare which the insect

gnaws and crushes decaying wood, and especially bark, with its mandibles, mixing the crushed material with saliva. In this way a pulp is made which is used in the construction of the nest, and dries into a kind of paper. The opening of the nest is in its under side (Fig. 88).

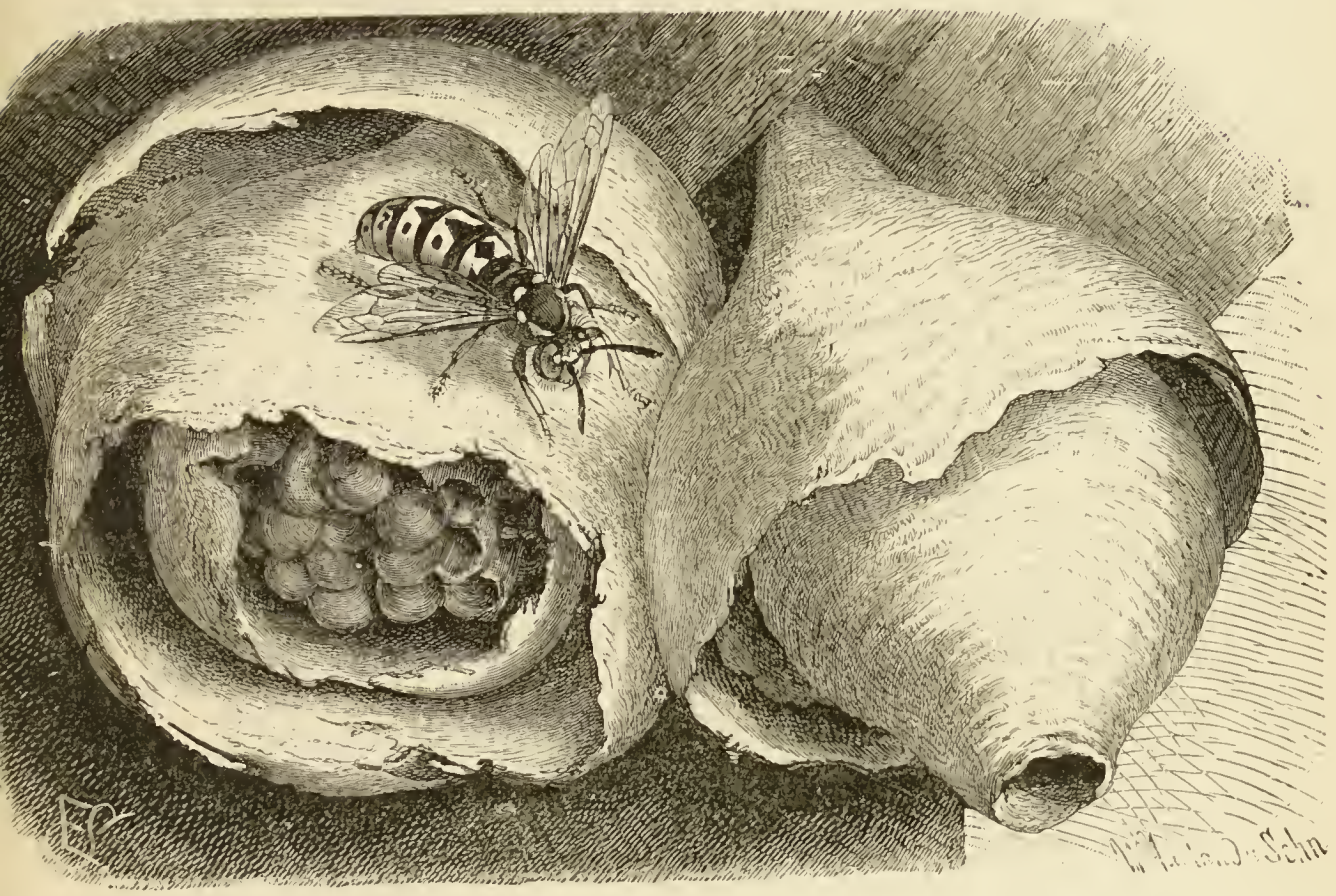

Fig. 88.—The Common Wasp (*Vespa vulgaris*) and its nest.

During spring and summer the queen, or "wasp-mother," lays only eggs from which workers are hatched, which undertake the work of nest-construction and care of larvæ, so that the queen can devote herself exclusively to the function of reproduction. Towards autumn males, and females capable of being fertilized, are also hatched; these last afterwards live over the winter in the fertilized condition.

During summer the larvæ are fed by the workers with finely chewed insects or with honey. They do not, however, suck the honey from flowers, but steal it

from several species of bee, or else form it in their stomachs from sugary materials drawn from sweet fruits.

Wasps are harmful or troublesome in three ways: (1) by gnawing the bark of trees; (2) by feeding on sweet fruits; (3) by the painful stings which they inflict. These are most dangerous in hot summer days. If a nest situated in the soil is destroyed during ploughing the alarmed insects attack both men and horses, cases being known where their stings have proved fatal. The pain is chiefly caused by the poison introduced into the wound. On this account if the sting remains sticking in the skin it must not be drawn out simply with the fingers, but carefully, by means of the nails, lest the poison-bag is pressed and thus still more poison brought into the wound. *Remedies:* Cooling substances, *e.g.* ground carrots, apples or pears, cabbage leaves, damp sand. Rubbing in ammonia. If there is acute inflammation, a compress with sugar of lead.

Family: **Fossores** (*Digging Wasps*).

Several species of this group resemble the wasps in their habits, as well as through their black and yellow-tinged abdomens; but they are always distinguished from these by their fore wings, which are not folded together in a state of rest, and by their eyes, which are not kidney-shaped. The shanks and feet possess thorns serviceable for digging. The sting of the female has no barbs, so that it is not torn off and left behind in the wound. The digging wasps are not social. They are lively and active; in summer the female often flies busily about near the ground in order to find a place for bringing up her young. She digs a hole in the earth in which she lays an egg. Then she buries an insect to serve as food for the young when hatched. Lest the insect to be buried

should decompose, while, on the other hand, a living animal would not allow itself to be buried, the wasp first brings the insect into a condition in which it cannot make any voluntary movements. For this purpose most species sting the captured prey several times in the body, and thus often injure the ventral ganglia (p. 84); by this treatment the insect is not killed, but reduced to a condition of apparent death. Most digging wasps are useful, since they chiefly bury destructive kinds of insects. The **Common Sand Wasp** (*Ammophila sabulosa*, Fig. 89), buries caterpillars;

FIG. 89.—The Common Sand Wasp (*Ammophila sabulosa*); natural size.

the **Path Wasp** (*Pompilius viaticus*), spiders; the **Weevil-killing Sand Wasp** (*Cerceris arenaria*) and the **Fly-killing Sand Wasp** (*Mellinus arvensis*) respectively bury weevils and flies.

Family: **Formicidæ** (*Ants*).

Large strong mandibles adapted for biting; maxillæ and lower lip not prolonged like a proboscis. Workers wingless; the males and reproductive females have weakly veined wings. In correspondence with these facts, the mesothorax which bears the larger wings is most strongly developed in the last, but the prothorax in the workers. Abdomen united with the thorax by a one- (*Formica*) or two-jointed (*Myrmica*) stalk. All female ants, and naturally workers too, possess poison-glands, the secretion of which accumulates in a poison-bladder; but the sting is lacking in all species of *Formica*. The stingless ants (*e.g.*

the Red Wood Ant, *F. rufa*) inflict a wound with their strong mandibles, and then, bending the abdomen forwards under the thorax, squirt the contents of the poison-bladder into the wound. Ants form colonies, always of large size, and consisting of reproductive and sterile individuals. Their food is both of animal and vegetable nature, but chiefly consists of insects and similar small animals. They mostly devour caterpillars, but also dead or wounded beetles (*e.g.* cockchafers), mammals, birds, and reptiles. As destroyers of caterpillars they are of use, but this is true more of those living in woods than those which inhabit fields and meadows. Ants are fond of all sweet substances; when they enter houses the sugar jar is very often the end they have in view. They are particularly fond of licking up the sweet juice which aphides excrete from their abdomens. On plants infested with aphides many ants are found which greedily sip up all the drops hanging from the abdomens of the aphides; they may even promote the shedding of the juice by stroking the abdomens of the little animals with their antennæ. There are, indeed, species of ants which carry the aphides to the plant parts on which they thrive best, and again, when these are sucked dry, transport them to other uninjured parts. Sometimes aphides are kept in the overground or underground nests of the ants. The common yellow meadow ants shelter aphides in their subterranean nests, where they live on the roots of grasses and other plants. In order to get, when necessary, fresh food for these "milch kine," they occasionally enlarge the nest, so that new plant roots are laid bare, and they then carry the aphides to these.

During the greater part of the year only workers, larvæ, and pupæ are found in an ants' nest, but reproductive individuals appear in summer, disappearing again before the cold weather comes on. As

soon as there is a sunshiny day they fly out, usually in large numbers. After pairing, the females let themselves fall to the ground; they then either tear off their own wings or this is done for them by the workers, which search them out and take them to the nest, where the laying of eggs quickly begins. The legless larvæ have feebly developed mouth-parts, and are fed by the workers on food broken down by them. The pupæ vary; in the sting-bearing ants (*Myrmica*) they are naked, in the stingless ants (*Formica*), on the other hand, they are invested in a cocoon. The latter kind of pupæ, known by the incorrect name of "ants' eggs," are collected and used as food for insect-eating birds. The nests are made either out of pine-needles and small branches heaped together (**Red Wood Ant** = *Formica rufa*), or they eat out passages and cell-like spaces in sound tree trunks (the larger **Wood Ants**, e.g. *F. herculeana* and *F. ligniperda*) or in decayed tree trunks (**Small Wood Ant** = *F. fuliginosa*); others (**Yellow Wood Ants** = *F. flava*, etc.) make passages and cavities in the ground, throwing up the earth into ant-hills. *Damage:* Several species do harm by excavating the soil, either in meadows and corn-fields, by which the plants are killed and harvesting rendered difficult, or under summer-houses and dwelling-rooms. Others destroy tree stems. They are indirectly harmful on account of the way in which they care for aphides, causing these pests to increase to a greater extent than would otherwise be the case. *Remedies:* If ants have got into a room the nest must be found if possible, and the insects there destroyed with paraffin or boiling water. If it proves to be too difficult to find and destroy the nest, all the openings by which the ants can enter must be stopped up with lime to which some extract of colocynth has been added. The nests found in fields and gardens may sometimes be destroyed by quickly digging them up, pouring paraffin over them, and

then igniting it. It is also a good plan to frequently tread or roll down the ant-hills which are thrown up, as in this way they will be dispersed in the end. Ants are of service in forestry, but scarcely in agriculture.

Family: **Ichneumonidæ** (*Ichneumon Flies*).

The species of ichneumon flies deviate in many ways from one another, but they all have similar habits and play a similar part in nature. They all have a longer or shorter ovipositor, always surrounded by two flaps, and serving for laying eggs in other animals. Those which seek their prey in branches and leaves generally possess a very short ovipositor not obvious on cursory examination; those which lay their eggs in insects inhabiting crevices, *e.g.* wood insects, are often provided with a very long ovipositor. No colonies and, consequently, no workers.

The female ichneumon fly generally lays her eggs in the body of an insect larva, on which the ichneumon larvæ developed from these eggs feed, using up the reserve matter stored up in the fat body (p. 92). Caterpillars are most infested; then follow false caterpillars, and then the larvæ of weevils and leaf beetles. The eggs of a few kinds are laid in pupæ, or even in the eggs of moths and butterflies. They always select for this purpose those insects which possess reserve material. The large kinds of ichneumon fly lay only a single egg in one host, especially if the latter is not of large size; many of the smaller ichneumons, on the other hand, lay many eggs (Fig. 90) in one host, even up to a hundred or more. A caterpillar containing ichneumon eggs does not at first appear different from other caterpillars, except that a dark spot or patch usually indicates where its body was pierced by the ovipositor of the ichneumon fly. The parasite breathes while in the

host by bringing the tip of its abdomen (where the main stem of the air-tube system opens) into connection with one of the host's spiracles. Since the larva feeds altogether upon perfectly digestible substances an anus is superfluous and is absent. Many ichneumon larvæ are ready to become pupæ when the host is about to pass into the same condition; the larva then bores through the skin of the latter, which quickly dies. Other species do not attack the organs of the host so soon, but allow it to become a

Fig. 90.—The Yellow-legged Ichneumon Fly (*Microgaster glomeratus*) of the Cabbage Caterpillar. Left, the adult insect; right, the larva (both enlarged). In the middle, Cabbage Caterpillar and a heap of Microgaster pupæ.

pupa in peace, and then themselves become pupæ inside it; later on, one or several ichneumon flies come out of this pupa instead of a moth or butterfly. It is obvious that ichneumon flies are very serviceable by destroying a large number of harmful insects. They cannot, indeed, prevent the increase of any particular noxious insect, but, when this takes place, they themselves increase to a greater extent, and finally appear in such numbers as to make an end of the pest.

I shall not enumerate here all the various ichneumon flies which benefit agriculture, but simply mention the **Small Cabbage Caterpillar Ichneumon Fly** (*Microgaster glomeratus*), depicted in Fig. 90, which, like its host (the large cabbage white), appears in two generations. The larvæ of the ichneumon fly live in large numbers in the large cabbage caterpillar, and at their last moult acquire minute teeth, with which they bite through the skin of their host; they then

leave it to die, and surround themselves with a cocoon close to its dead body. There are, besides, a few small and also some large ichneumon flies which lay their eggs in the pupæ of the cabbage white, so that, *e.g.*, in winter many of its angular pupæ, occurring on tree-stems and hedges, are found with many small or several large white ichneumon larvæ within them.

Family: **Tenthredinidæ** (*Saw-flies*).

Body thick-set. Abdomen never very long, and united by a broad base to the thorax (Fig. 91). Saw-shaped ovipositor (p. 89), drawn in when not in use, and only protruded during egg-laying. Mandibles strong, the remaining mouth-parts not so well developed. The larvæ are false caterpillars (p. 92); they can usually be recognized by their characteristic attitude, for many of them bend the abdomen very much upwards and forwards, especially when frightened, and when at rest the hinder part of the body is spirally coiled (Fig. 91). The fully developed larva spins a cocoon in which it still remains for a long time in the larval condition, even during the whole winter. It becomes a pupa two or three weeks before the appearance of the perfect insect. There are many larvæ of this kind destructive to woods, but only a few which interest the farmer. Here is included—

The **Turnip Saw-fly** (*Athalia spinarum*).

Adult: Female one-third of an inch long, stretch of wing over two-thirds of an inch; male somewhat smaller. Bright orange or reddish yellow. Head black, thorax and legs with black markings. Wings large. *Larva:* Length may be rather more than two-thirds of an inch. The just-hatched larvæ are almost colourless, but the skin quickly becomes bright

green, and after the first moult, dark green to black. Ventral side slate grey. Head shining black. Twelve broad body segments, upon which are many wrinkles of the skin.

The sluggish adult is found, during May or August, upon kohl rabi and turnips, mustard and charlock, with its wings folded together. The female, by means of her ovipositor, saws small holes in the margin or under side of the leaf, and lays her eggs in these. The larvæ are hatched in from four to six days, and they undergo four moults. The presence of the larvæ can be detected by their cast skins, which remain sticking to the leaves even when the animals

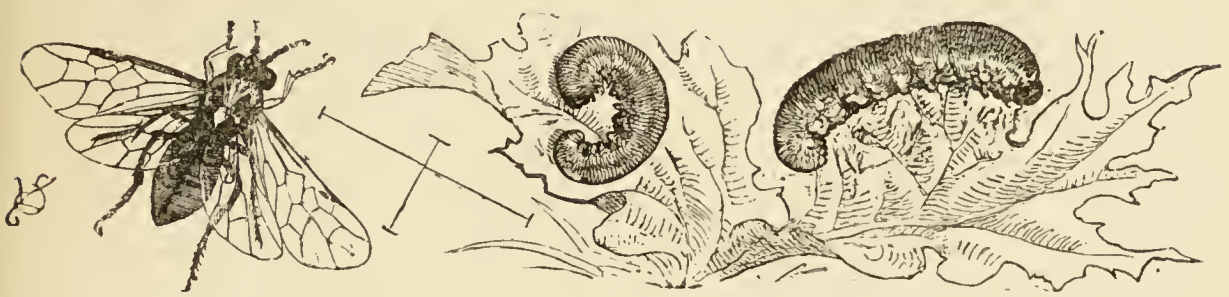

FIG. 91.—The Turnip Saw-fly (*Athalia spinarum*): adult female and two caterpillars.

themselves, which are often found rolled up on the under sides of the leaves, cannot be seen. The enemy is also known by its way of feeding, for the larvæ keep on the surfaces of the leaves (upper or under surface) and eat out longish holes. As soon as these have reached a certain size, other parts of the leaves or other leaves are attacked. When the larvæ are numerous the holes continually increase in number until only the leaf-ribs are left. The mature larvæ creep into the soil to a depth of from two-fifths to four-fifths of an inch, and spin a small cocoon. The saw-fly emerges either the same or the following year. These insects may therefore appear in May or in August, but in many cases they are seen at only one of these times, either the summer or autumn turnips being attacked, as the case may be. *Remedies:* Fowls and ducks willingly eat the larvæ, and, provided they

are not able to do any damage, can therefore be brought into the fields. Strewing with soot has a good effect. It pays to pick off the larvæ from young plants.

Order 5: **Lepidoptera** (Butterflies and Moths).

Sucking mouth-parts, forming a "proboscis" made up of the two very long maxillæ, spirally rolled up under the head when not in use (Fig. 92), and adapted for sucking honey. There are some forms which take no food in the adult condition, and in which the proboscis is short; in a few species of hawk-moths, this organ is even longer than the body. The larvæ ("caterpillars") have biting mouth-parts. The body

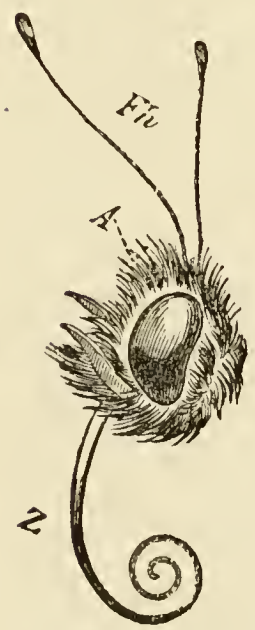

Fig. 92.—Head of a Butterfly. A, eye; *Fh*, antennæ; Z, proboscis.

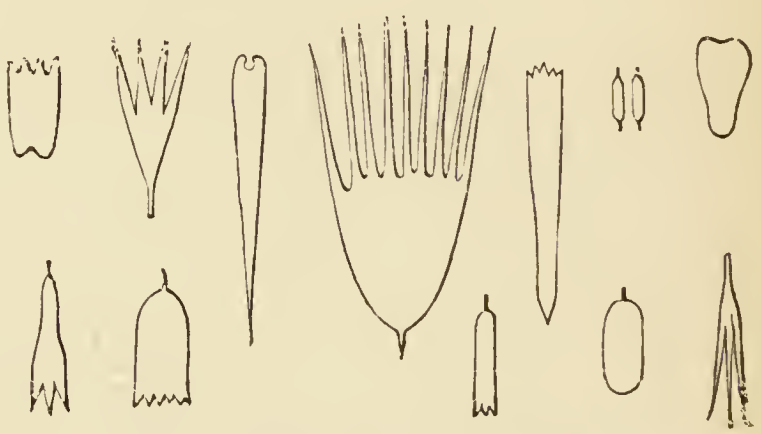

Fig. 93.—Scales from a Butterfly's Wing (strongly magnified).

of a butterfly or moth is covered with hair-like structures developed by the skin; in the wings these are broader, have a characteristic appearance (Fig. 93), and partially overlap one another. These scales cause the colours of the wing. They can easily be wiped off, leaving the corresponding part of the wing

transparent and clear as glass. In many species (all hawk-moths, many owlet moths) there is a *wing-hooklet*, i.e. the hind wing has a spine or a thick brush which grasps a band-like area of the fore wing. In this way the two pairs of wings are held together. The females of a few species of spinner and looper moths are wingless, or only possess short flap-like wings useless for flight. The metamorphosis is complete (p. 89); the larvæ are true caterpillars; the pupæ are obtectate (p. 93). Many caterpillars creep into the ground to become pupæ, and spin no investment at all (*e.g.* hawk-moths). Others make a cocoon, which may consist of threads loosely woven together or may be of firm texture (Fig. 60). The cocoon consists chiefly of silk, a substance secreted in a spinning gland, and exuding to the exterior on the lower lip; but minute particles of sand or earth, and fragments of wood gnawed off by the caterpillar, may be stuck in the cocoon. The pupæ of butterflies are naked, without cocoon, but are fixed by threads to leaves, tree stems, walls, hedges, etc. A distinction is drawn between girdled and suspended pupæ; the first are fixed by a silk band, which surrounds them, and the head is directed upwards, while the latter are suspended by the tip of the abdomen (Fig. 94). The time required for the development of the perfect insect from the pupa is not always the same, depending not only upon the species, but also upon the time of year. The summer generation of the large white spends scarcely fourteen days in the pupa stage, the winter generation eight months.

Family: **Diurna** (*Butterflies*).

Body relatively weak and thin; wings very broad, not very long relatively. No wing-hooklet (*see above*). Wings folded together above in a state of rest, so that their upper sides touch. Antennæ thickened in

a club-like way at the tip. The caterpillars possess five pairs of pro-legs; they are usually almost devoid of hair. There are, however, a few (*e.g.* the caterpillar of the peacock butterfly, Fig. 94) which possess hard, spine-like, much-branched bristles. The naked pupæ are sharp cornered; some are girdled, others suspended (p. 137).

Among butterflies with larvæ that become suspended pupæ are the **Red Admiral** (*Vanessa atalanta*), the **Peacock** (*Vanessa io*, Fig. 94), the **Fritillaries** (*Argynnis*), the **Meadow Browns** (*Hipparchia*), etc.; and among those with girdled pupæ the **Swallow Tail** (*Papilio machaon*), the **Whites** (*Pieris*), etc.

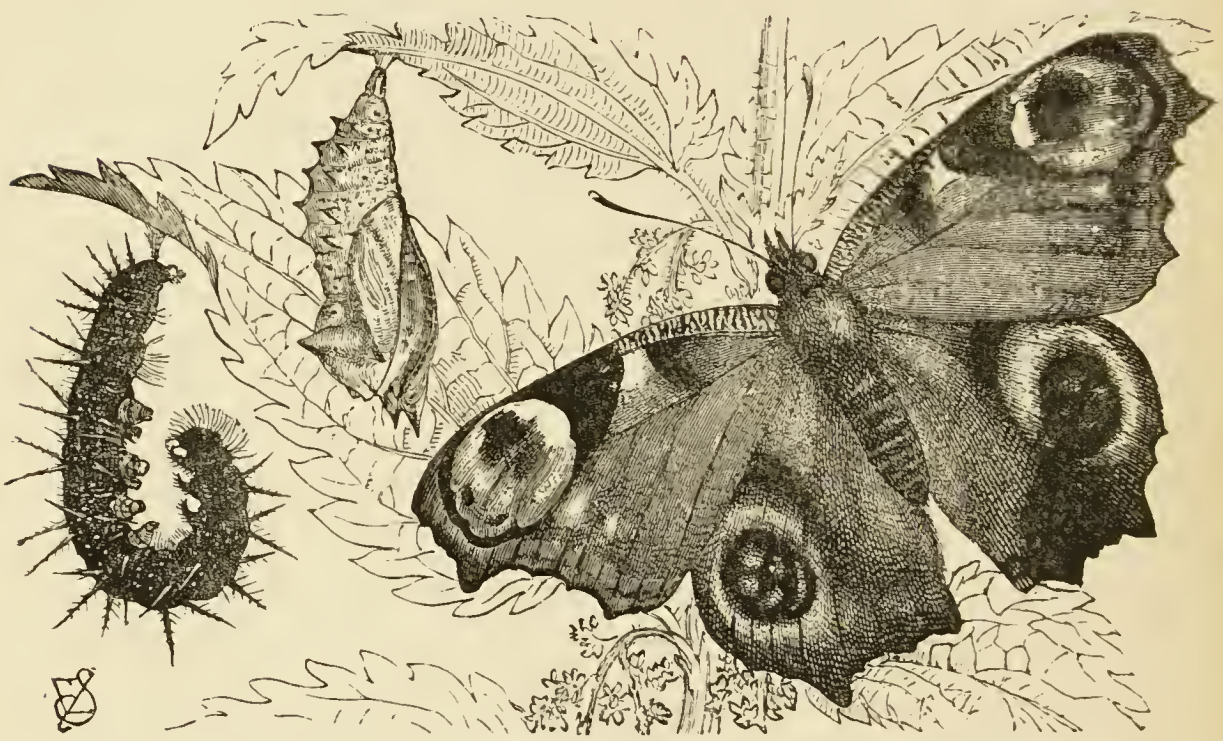

Fig. 94.—The Peacock Butterfly (*Vanessa io*), with pupa, and larva suspended before passing into the pupa state.

The **Cabbage White**, or **Large White** (*Pieris Brassicæ*).

Butterfly: Length a little over an inch, span of wing $2\frac{1}{2}$ inches. Both fore and hind wings milky white, the former black at the root, on the front edge, and the outer angle; also a black patch on the inner margin of the fore wing, passing on to the front

margin of the hind wing. The female possesses, in addition, two round black patches on the middle of each fore wing. Under side of the fore wings milky white, yellow at the tip, blackish at the root; under side of the hind wings yellow, with black dots. *Caterpillar* (Fig. 95): As much as $1\frac{1}{3}$ inch long; greenish, or sulphur yellow, with black dots. Head and dorsal side of last segment of the body grey with black spots. Young specimens are of a very bright green with black wartlets closely crowded together.

From the pupæ which have lived through the winter butterflies emerge in May, and lay their golden yellow eggs in small heaps on the under sides of the

Fig. 95.—The Cabbage White (*Pieris brassicæ*) female laying her eggs; caterpillar, and pupa.

leaves of rape, mustard, and cress, also on charlock and such-like cruciferous weeds. The caterpillars of this first generation are hatched in fourteen days, and rarely do any harm, since they only appear in small numbers. They develop rapidly, and during the last days of June become pupæ on the branches and leaves of the plants they live on; the butterflies appear in July. Owing to their rapid development the caterpillars and pupæ of this first generation are but little exposed to the attacks of enemies

(ichneumons, birds, etc.). Only a few of them die, therefore, if the weather is favourable. As a result of this, the July butterflies and the eggs laid by them are relatively numerous, so that the number of caterpillars appearing in late summer may be very large. These caterpillars, however, live almost exclusively on the various kinds of cabbage and kohl rabi, and it is this second generation which in many years is so harmful. At the beginning of August the caterpillars are ready to become pupæ, and for this purpose they seek tree stems, hedges, walls, etc. The pupæ now formed live as such through the winter. During this period, however, they are exposed to many dangers (damp, cold, sudden alternation between very low and very high temperatures; ichneumons, birds), and most of them perish, so that only a few butterflies come out the following spring, and lay but a few eggs. It is therefore obvious that the first generation of caterpillars (May, June) is much less numerous than the second generation occurring from late summer to autumn. Under exceptionally favourable conditions even a third generation may appear, since caterpillars of the second generation are able to become pupæ at the beginning of August; and these pupæ, instead of remaining as such over winter, become butterflies the same month. These, again, lay eggs from which the caterpillars of the third generation are hatched, which, however, are not always fully developed before the advent of the cold weather, and in this case perish. It is clear that, in the case of pupæ which develop into butterflies during August in about fourteen days, the unfavourable influences have either no effect (unfavourable weather) or but little (ichneumons, birds), so that the butterflies appear in flocks, which wander into other regions, since they have themselves, when larvæ, devoured the cabbage and turnip plants. In reference to the damage effected by the caterpillar, it may be observed

that only the chief veins of the leaf are left, and the margins are not spared. *Remedies*: Collection of the little heaps of yellow eggs and the young caterpillars, which are blackish and live together in small companies; the planting of a few small hemp plants in the cabbage fields to be protected, by which the butterflies will be kept away.

The **Garden White**, or **Small White** (*Pieris rapæ*).

Butterfly (Figs. 96 and 97): Length rather less than an inch, span of wing two inches; very much like the cabbage white. Base and tip of the fore wing not of such a deep black colour; the black patch in the inner margin of the fore wing is usually absent in the female. The male, however, very often has a black patch in the upper side of the fore wing. *Caterpillar*: Just over an inch long. Dull green; a longitudinal yellow line on the back; also the black stigmata are connected by a yellow line. Habits as in the preceding species; the female, however, lays her yellow eggs separately, and not in heaps, and the second generation of caterpillars usually become pupæ somewhat later in the year. Collecting is more

FIG. 96.—The Garden White (*Pieris rapæ*), male.

FIG. 97.—The Garden White (*Pieris rapæ*), female, caterpillar.

difficult than in the preceding species, since the young caterpillars live independently, and their colour makes it difficult to recognize them on the green cabbage leaves.

The **Green-veined White** (*Pieris napi*).

Butterfly (Fig. 98): As large or somewhat smaller than the preceding species. Wings milky white on their upper side; fore wings dusted with black on their front margin, tips, and ends of the ribs. Two spots on the middle of the fore wing in the female, one or none in the male. Under side of the hind wings yellow; under side of the veins dusted with greenish-grey. *Caterpillar:* A little over an inch. Dull bluish-green, with minute blackish tubercles above, and whitish ones below. A yellow longitudinal line on each side connecting the black spiracles, which are bordered by reddish yellow. Very like the preceding species in the larval condition. Habits as in the preceding species, but this is less common.

FIG. 98.—The Green-veined White (*Pieris napi*).

Family: **Noctuidæ** (*Owlet Moths*).

Night-flying moths, of medium size and dull colour, with smooth-haired bodies. Antennæ long and thin, thread like,—comb-shaped only in the males of a few species; wings powerful, lie in a roof-like way when at rest; almost always a wing-hooklet. Caterpillars usually hairless; mostly with five pairs of pro-legs, a few with four or three pairs. The owlets pair at night; they also fly about during the day, even in bright sunshine. Flight strong and rapid, but always in fits and starts. Almost all species lay their eggs

separately, and on herbs, only a few species on trees. The caterpillars are very much scattered, and the damage caused by them is never great, except in spots here and there,—on the contrary, when they increase to a great extent they spread over a wider area. Several species are harmful to agriculture.

The **Surface Caterpillars** (Species of *Agrotis*)

are stout caterpillars, $1\frac{1}{5}$ to 2 inches long, with five pairs of pro-legs, and shining transparent external skin. They remain in the ground during the day, feeding above ground at night, and also in the day-time when the sky is much overcast. When touched they bend themselves into the form of a C. There are in Britain several species of surface caterpillars which have these habits, but I will only describe here, to begin with, the commonest kind :—

The **Common Dart** or **Turnip Moth** (*Agrotis segetum* or *A. clavis*).—*Moth* (Fig. 99) : Length almost $\frac{4}{5}$ of an

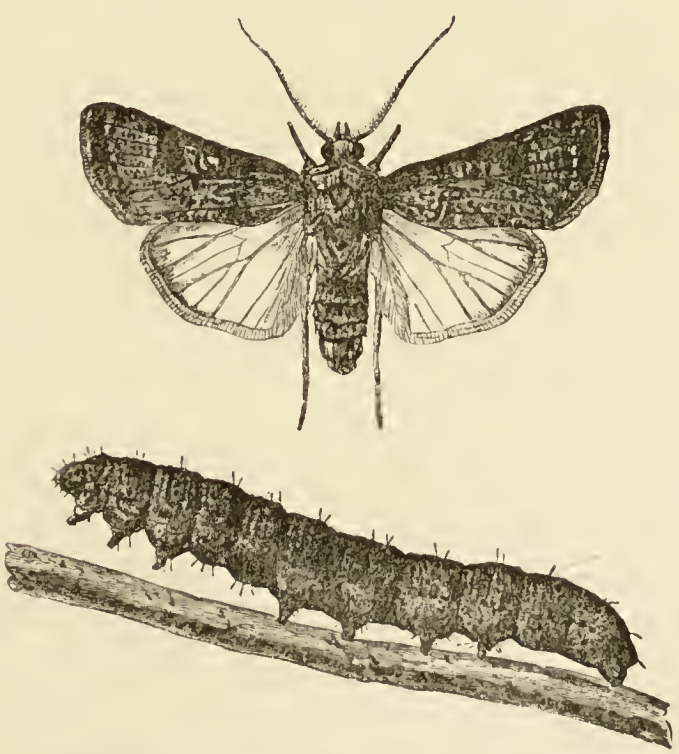

Fig. 99.—The Common Dart or Turnip Moth (*Agrotis segetum*) with Caterpillar.

inch. Span of wing about $1\frac{4}{5}$ inch. Fore wings small, ash-grey or brownish, with many dark patches and

similar markings. Hind wings in the male, bright grey to snowy white; in the female, brownish grey. *Caterpillar* (Fig. 99): Up to two inches, earthy grey, occasionally somewhat greenish. Head and prothorax darker. The time taken by the caterpillars to complete their development differs according to the plants attacked, and it is therefore easy to understand why the moths should be seen flying about from the first half of May right on into the autumn, without having recourse to the improbable hypothesis of two successive generations. The eggs are consequently laid at very different times, and are always deposited singly in the soil in the neighbourhood of plant roots, or else in the low-lying leaves and stems of various herbs. The caterpillars hatched from these are destructive earlier or later, according to the time of egg-laying. Most specimens are half grown in winter; these continue their destructive work the following spring. In autumn they attack the roots of winter grain (rye and wheat), rape, and species of cabbage; they also bore readily into turnips and potatoes. In spring, after the winter rest, they continue to attack the roots of winter grain, winter rape, etc., or fleshy underground parts (turnips, potatoes) developed in the interim, or the roots of summer plants (summer grain, buckwheat, summer rape, vegetables, etc.). On clear days the caterpillars always remain hidden in the soil; and those which have bored into juicy underground parts of plants (turnips, carrots), do not leave their abode during the day, but the others, both during the night and on cloudy days, come above ground to attack the leaves and stems of young plants. In exceptional cases the caterpillar is mature by the beginning of winter, in which case it hybernates in the soil as a brown pupa. The moths escaping from such pupæ naturally appear earlier than others. As a rule, the caterpillars do most damage to the winter crop in autumn, wandering about a great deal; in many cases

they gnaw through the main root, thus quickly killing the plant attacked, from which they proceed to another. *Remedies:* When the caterpillars have done much damage in late summer, it is recommended to leave the field alone till October, then to plough it up and sow the winter grain. By putting off the seed-time in this way, the caterpillars will have lost their activity when the corn germinates, and the winter crop will thus escape them. Besides this, the preceding ploughing will bring many caterpillars to the surface, where they will become the prey of birds, or, if not, can be collected. Warm soils, especially those manured with horse-dung, are most infested by the caterpillars; and the use of warm kinds of manure should, therefore, be avoided in regions which have much to fear from these insects. Where everything has been destroyed, a thorough ploughing is desirable. Swine may also be driven in during autumn, and will grub up and devour the caterpillars. In this case, sowing will take place the following spring.

Other *Surface Caterpillars*, which have pretty much the same habits as the preceding, are those of the **Heart and Dart Moth** (*Agrotis exclamationis*), the **Wheat Moth** (*A. tritici*), and the **Thick-bodied Surface Caterpillar** (*A. ravida* or *A. crassa*).

The **Cabbage Moth** (*Mamestra brassicæ*).

Moth (Fig. 100); about $\frac{11}{12}$ of an inch long, span of wing $1\frac{3}{5}$ inch. Fore wings shining brown, with yellowish and black marbling; each patch having a dark outline; a yellowish zigzag line on the outer margin. Hind wings shining yellowish-grey brown. A strongly developed crest in the middle line of the thorax. *Caterpillar* (Fig. 100): $1\frac{3}{5}$ inches, cylindrical. Bright or dark green, brownish green, or greenish brown. On the back a dark longitudinal stripe, divided into two halves by a narrow white longitudinal line.

A whitish line running along each side; between this and the dorsal line a dark transverse streak on each segment. The brown pupa (Fig. 100) remains in the soil during the winter, and is not invested in a cocoon. The moth appears in May; during the day it rests on windows, in barns, etc. The greenish yellow eggs are laid separately on the leaves of cabbages (sometimes also on lettuces and turnips). The caterpillars, which appear in fourteen days, creep about actively between the leaves. Within a month they are full-

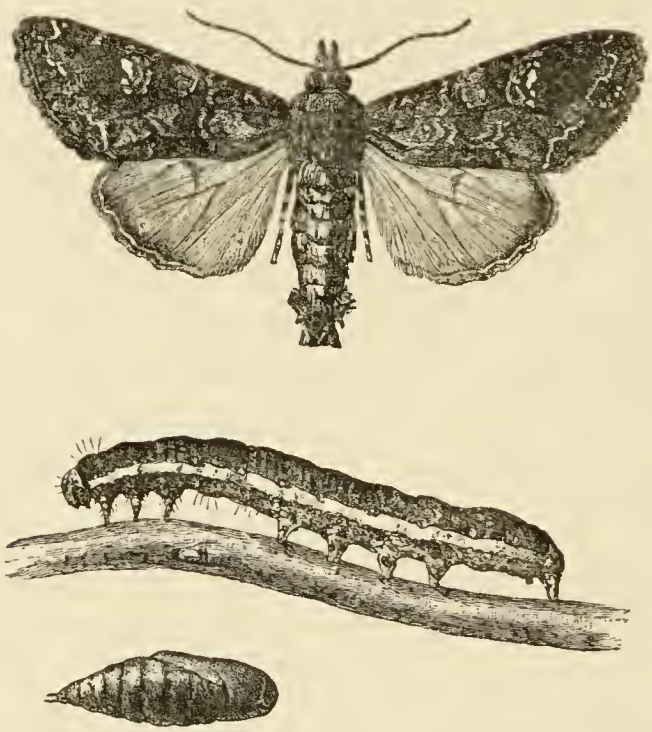

FIG. 100.—The Cabbage Moth (*Mamestra brassicæ*), with caterpillar and pupa.

grown, and become pupæ in the soil. At the end of July and in August the summer generation of moths appears. From the eggs laid by these are hatched a second generation of caterpillars, which are always much more numerous than those of the first. From August to October they are found in all kinds of cabbage, especially compactly headed kinds and cauliflower. At first they eat holes in the leaves, leaving, however, the chief veins and usually the edges. Later on they eat right on into the heart of the cabbage. They fill their burrows with excrement, and the

attacked plants begin to rot internally. The full-grown caterpillars creep out and become pupa in the soil. *Remedy:* Collecting the caterpillars while they are still on the outer leaves.

The **Vegetable** or **Lettuce Moth** (*Mamestra oleracea*).

Moth: $\frac{3}{5}$ of an inch long; span of wings about $1\frac{2}{5}$ of an inch. Fore wings dark rusty brown, darker on the nerves, dusted with white. Hind wings reddish white. Head and thorax like the fore wings; abdomen like the hind wings. *Caterpillar:* Up to $1\frac{3}{5}$ inch; dirty greenish grey, or olive green, irregularly bestrewn with dirty white dots. The caterpillars feed on cabbages, lettuce, asparagus, and other vegetables. Those of the first generation (June and July) hollow out lettuce stalks before the head begins to be formed; those of the second generation (August and September) feed on cabbage or asparagus leaves. The first generation of moths appear in May, the second in the first half of August.

The **Pea Moth** (*Mamestra pisi*).

Moth: About $\frac{2}{5}$ of an inch long; span of wings about $1\frac{2}{5}$ of an inch. Fore wings bright reddish brown with bluish-grey markings, and a yellowish longitudinal streak. Hind wings reddish grey. *Caterpillar:* $1\frac{4}{5}$ of a inch; cylindrical; slender. Back dark greenish or brown red; closely and tolerably regularly veined with dark lines, and with two sulphur yellow longitudinal streaks on the back and one on each side. Head, belly, and feet flesh red. If the caterpillar is touched it moves the front part of its body about here and there, and then lets itself fall down. The moths appear in May and June; the caterpillars are found from July to September on peas, vetches, beans, clover, lupins, sorrel, orach, heath, willow, birch, and yet other plants. Seldom very destructive.

The **Grass-root Moth** (*Hadena monoglypha*, or *H. polyodon*).

Moth: About $\frac{7}{8}$ of an inch long; span of wing $1\frac{4}{5}$ inches. Fore wings longish; yellow brown blended with dark brown and white; the tips are coloured most brightly. Three black rays on the fore wing; hind wings brown grey. *Caterpillar:* About $1\frac{3}{5}$ inches long, $\frac{1}{3}$ of an inch broad, with sixteen feet. Grey or reddish white, more or less shining. Head, prothorax, the last body-segment and warts black. At the end of July and during August the female lays her eggs separately on the bases of grass haulms and leaves. The caterpillars creep out at the end of August, and, especially after their hybernation (in April and May), attack meadow grasses, biting through the leaves and haulms at their bases, immediately above the surface of the ground, and devouring, as it were, passages through the grass. The reddish-brown pupæ rest in the soil.

The **Couch-grass Moth** (*Hadena basilinea*).

Moth: Nearly $\frac{4}{5}$ of an inch long; span of wings $1\frac{3}{5}$ inches. Head and back rust-coloured or reddish grey, in the male with a large tuft of hairs. Fore wings coloured like the back, with two transverse lines in the middle, and brighter and darker marks as well. Hind wings bright brown, with a faint golden sheen, and with a yellowish fringe. *Caterpillar:* $1\frac{1}{5}$ to $1\frac{2}{5}$ inches long, with sixteen feet, bluish grey, somewhat brownish, with dirty white longitudinal lines; greenish belly, and large bright brown head. The moth lays the eggs in little heaps on the stems and leaves of grass plants. The damage which the caterpillars effect among meadow grasses is inconsiderable; but they sometimes appear in considerable numbers on grain-plants, and are then very destructive. The

insects are chiefly found on dry high-lying land, which is consequently most liable to the attacks of their larvæ. After hybernation they feed on grass or the leaves and stems of young grain-plants, and change in the soil into stout, smooth, yellowish-brown pupæ, devoid of cocoon. *Remedy:* In case the caterpillars have got into the crop, threshing should take place as soon as possible, or, after hybernating, they will continue to devour the grain in the barns.

The **Wheat-haulm Moth** (*Luperina didyma*).

Moth: Span of wing $1\frac{1}{5}$ inches. Individual specimens differ very much from one another: brownish, greyish yellow to ochre yellow, with various dark and light markings. *Caterpillar:* With sixteen legs, and over an inch long in full-grown specimens (May); thin, spindle-shaped; stiff; bright shining green, with two broad dark red lines on the back. The caterpillars live in the stalks of wheat-plants, and other gramineous forms, hollowing them out; they hybernate when tolerably young. In spring they continue to hollow out the wheat plants, going from one stalk to another. The plants attacked quickly have their leaves turned to a rusty colour, and they sicken or even die.

The **Grass Moth** (*Charæas graminis*).

Moth: Length $\frac{3}{5}$ of an inch; span of wings about $1\frac{1}{3}$ inches. Antennæ of the male comb-like. Fore wings short, of a brownish-red, olive-brown, or dirty olive-green ground colour, with three whitish patches, and darker markings. Hind wings yellowish grey, brighter at the roots. *Caterpillar:* With sixteen legs; $1\frac{4}{5}$ inches long; bronze grey, back more of a bronze brown, with three narrow bright longitudinal streaks. Head ochre yellow. The moth lays her some two hundred

eggs during July, in little heaps at the bases of the grass haulms and leaves. The caterpillars hide during the day, and feed at night. They are very injurious even in the autumn, but become insatiable the following spring, always devouring the lowest parts of the haulms and leaves, so that the upper

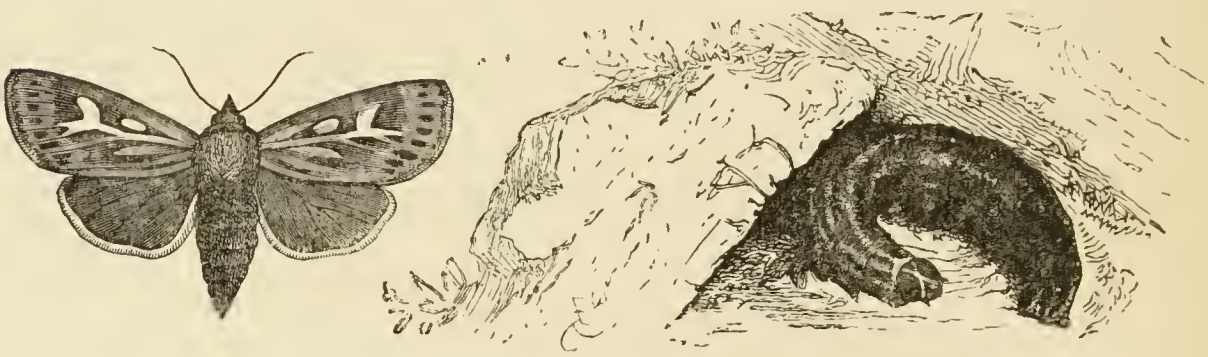

Fig. 101.—The Grass Moth (*Charœas graminis*) and its caterpillar.

parts die off. They wander in large companies from one field to another. In June they become pupæ of a shining reddish-brown below the surface of the soil or under sods. *Enemies:* swine, moles, shrews, rooks, wagtails, ducks, fowls. *Remedy:* Driving in swine, where this is practicable.

The **Darnel Moth** (*Neuronia popularis*).

Moth: Length rather less than $\frac{4}{5}$ of an inch; span of wings nearly $1\frac{3}{5}$ inches. Much variegated, beautiful. Fore legs reddish-brown, with peach-coloured glow; all the nerves and several markings yellowish white, and dark markings as well. Hind wings yellowish, and abdomen white. Head and thorax brown, mixed with yellowish white. *Caterpillar:* Over two inches long, and about one-third of an inch thick; 16-legged; tapers at both ends. Has an oily lustre. Dorsal side of a bronze brown, sharply marked off by a yellowish line from the bright brownish grey ventral side, and traversed by three longitudinal bright brown lines, which in young specimens are almost white. Habits pretty much like those of the preceding species.

The **Silver Y Moth** (*Plusia gamma*).

Moth: About $\frac{7}{8}$ of an inch long; span of wings $1\frac{3}{4}$ inches. Dark grey, mixed with a reddish tint, and darkly marbled. About the middle of the fore wing there is a very obvious gamma (γ), or Y-shaped mark. Hind wings bright brown at the root, darker at the margins, with a whitish fringe. A crest of hairs on the dorsal side of the thorax. *Caterpillar:* 12-legged. It bends its body like a looper (Fig. 102). Length 1 to $1\frac{1}{5}$ inches. Ground colour green; but there may be variations in this from a dirty green to a brownish

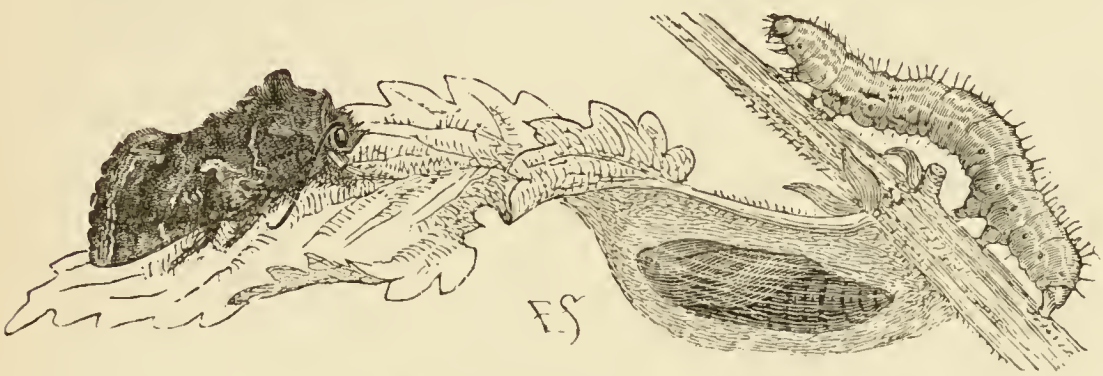

Fig. 102.—The Silver Y Moth (*Plusia gamma*), with caterpillar and pupa.

colour. Six fine longitudinal lines on the back, and a yellowish line above the legs. The caterpillar is almost naked, only possessing a few small, isolated bristle-like hairs. *Habits:* At least two generations, and sometimes as many as five in two years. The Silver Y Moth generally hybernates as a half-grown caterpillar, but sometimes also in the pupa, or moth state. The caterpillars may therefore be met with the whole year; but they are usually most abundant from the end of June to the middle of August, and, under favourable conditions, may become an agricultural pest. They devour the leaves of almost all wild and cultivated plants (except grasses, corn, and trees), and are especially fond of leguminous plants (peas, vetches, clover), flax, beet, rape, cabbage, and buckwheat. The moths mostly appear in May, but also in July, and later on in the summer, especially on

clear days. The female lays her numerous bright green eggs, some four hundred in number, separately, on the leaves of the above-named plants. The caterpillars are not always easy to see, owing to their greenish colour; under favourable conditions they may pass through the whole of their development up to the moth stage in from six to seven weeks. In some years they appear in such large numbers, that almost all the cultivated plants found in the fields of an infested region are utterly spoilt by them, excepting the corn. *Natural enemies:* Starlings, all sharp-beaked singing birds haunting fields; sparrows; ground beetles, rove beetles, and the larvæ of these families; several ichneumon flies, parasitic fungi. *Remedies:* Driving in poultry, where practicable. Collecting, *e.g.* by means of a machine invented by L. Dehoff, of Gutenberg, near Halle. "Several troughs with steep inner walls are fastened together by laths, at distances equal to those between adjacent furrows, and besoms are fixed to the laths. These troughs are drawn along like sledges by a horse walking in the furrows, and the caterpillars are swept by the besoms into the troughs, from which they are collected in sacks at the ends of the furrows. With this cheap machine about twelve acres per day can be cleared" (Taschenberg).

Family: **Pyralidæ** (*Snout Moths*).

Small moths with thread-like antennæ, comb-like in the males of a few species, with tolerably large eyes, and very large labial palps often stretched out in front like a beak (Fig. 103). Fore wings of an elongated triangular shape. Wing hooklets. Legs tolerably long. Caterpillars slightly hairy, with four or five pairs of pro-legs.

The **Rye Snout Moth** (*Pyralis secalis*).

Moth: $\frac{3}{5}$ of an inch long, span of wings $1\frac{1}{5}$ inches.

Wings elongated, whitish grey, with an A-shaped patch on the fore wings. *Caterpillar:* Rather more than $\frac{2}{5}$ of an inch long; green, streaked with brown, 16-legged, with a brown head, and tapering at both ends. *Habits:* The caterpillar lives during June in the rye haulms, hollowing them out. As a result of this, the ears remain hidden between the leaves and leaf-sheaths, and it often happens that only the tips of the awns appear externally. No grain is formed; the ears first become white and dry, and then fall off.

The **Hop Snout Moth** (*Hypena rostralis*).

Moth (Fig. 103): Length rather less than $\frac{2}{5}$ of an inch; span of wings $1\frac{1}{5}$ inches, or more. Fore wings usually brownish, somewhat scalloped on the fringed outer margins; a zigzag black line near the base; in the middle, near the front edge, a patch bordered with white, and behind this a dark longitudinal streak. Hind wings dull grey, with a silky sheen. *Caterpillar:* At most one inch long, 14-legged, very slender, green, with a dark middle line and two white side lines. Very active; wriggles about on the ground like an eel. *Habits:* The moth is on the wing at the beginning of August, the second generation in August; the latter hybernates in outhouses, barns, summer-houses, etc. The eggs are laid on wild and cultivated hops, also on stinging nettles. The caterpillars are found on the hop plants, especially in June; they sometimes entirely devour the leaves, with the exception of the nerves. In July they become pupæ, either between the leaves or on the soil, and are invested in a grey cocoon. The moths appear at the beginning of August, and give rise to a second generation of caterpillars, from which, after the pupa stage, the moths which live through the winter are developed.

Fig. 103.—The Hop Snout Moth (*Hypena rostralis*).

The **Cabbage Snout Moth** (*Botys forficalis*).

Moth: Length about half an inch. Span of wings rather over one inch. Fore wings sharply bent in front before their sharp tips; rusty yellow, somewhat darker on the nerves, with rusty brown transverse streaks from the outermost corners to the middle of the hinder margin, and with other reddish-brown markings. Hind wings and body shining straw yellow. *Caterpillar:* $\frac{4}{5}$ inch long, 16-legged, tapering in front and behind. Yellowish green, with indistinct longitudinal lines and bright brown head. A few small yellowish-green hairs. *Habits:* The first generation appear in small numbers in May. The caterpillars hatched out from the eggs of these live (May and June) on the leaves of cabbages and wild cruciferous plants. They always shelter themselves between the leaves, and spin a few thin threads across the entrances to their abodes. The caterpillars burrow horizontally in the earth, and there become pupæ invested in cocoons. The moths of the second generation appear in August; in autumn the caterpillars hatched from their eggs damage cabbages, sometimes to a large extent. In October they burrow into the soil, where they hybernate. *Remedy:* Deep digging or ploughing after the crop, by which the larvæ invested in webs are buried deeply, and consequently for the most part killed.

The **Mother-of-pearl Moth** (*Botys margaritalis* = *B. extimalis*).

Moth (Fig. 104): Length nearly $\frac{2}{5}$ inch; span of wing over $1\frac{1}{5}$ inches. Fore wings bright sulphur yellow, with large rust-coloured patches, and two rusty yellow transverse lines. Hind wings shining straw yellow; all four wings with a mother-of-pearl sheen. *Caterpillar* (Fig. 104): $\frac{4}{5}$ inch, 16-legged, yellowish,

head and neck-shield black. Body with a broad, grey, longitudinal streak on each side. Four longitudinal rows of dark brown warts. *Habits:* The moth is on the wing in June and July, and lays the longish ovoid eggs on cruciferous plants (rape, radish, several wild forms). The caterpillar lives concealed in a white web, and gnaws holes in the pods, into

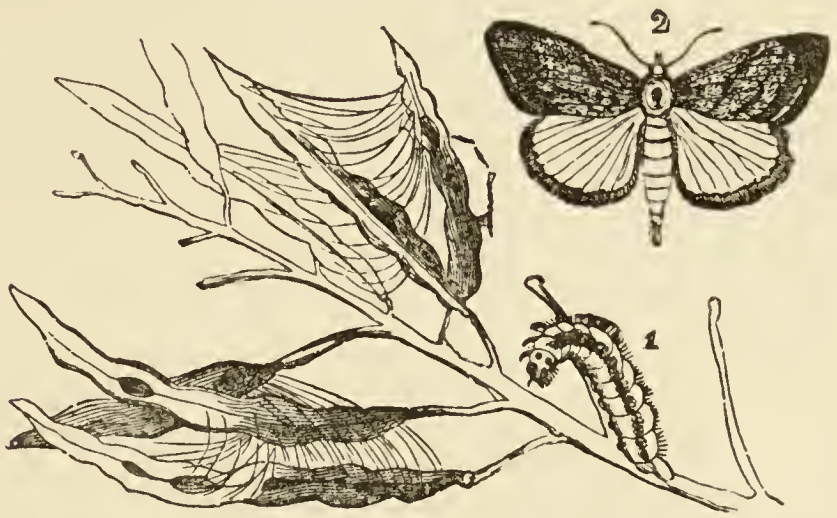

Fig. 104.—The Mother-of-pearl Moth (*Botys margaritalis*), with larva (1) and injured pods.

which it inserts the forepart of its body for the purpose of devouring the still green seeds. The attacked pods, owing to the presence of round holes in them, look something like flutes or fifes.

The full-grown caterpillars burrow into the soil, where they hybernate in a delicate web. *Remedy:* Compare the preceding species.

Family: **Tortricidæ** (*Leaf-rollers*).

Small, thickset moths (Fig. 105), with smaller palps than the snout moths. Fore wings broad at the root, with straight or somewhat curved outer margins. Hind wings as broad, or even broader, than the fore wings. When at rest the fore wings lie in a roof-like way. They usually possess many characteristic markings. Hind wings greyish, without markings. Antennæ thread-like. Caterpillars

hairless, or only slightly hairy; 16-legged: many kinds live in leaves, which they roll up; others in twigs, buds, and fruits, which they hollow out.

The **Fawn-coloured Pea Moth** (*Grapholitha nebritana* = *G. pisana*).

Moth (Fig. 105): Length $\frac{3}{8}$ inch; span of wings about $\frac{2}{5}$ inch. Fore wings fawn-coloured, with metallic sheen; alternating short, white, and dark lines on the front margin. Hind wings black, with bronze sheen and white fringe. *Caterpillar:* $\frac{1}{3}$ inch long; 16-legged; pale green, with brown or black head, neck-shield, and last body segment. The thoracic legs are black. Dark warts on each segment. *Habits:* Compare the succeeding species.

FIG. 105.—The Fawn-coloured Pea Moth (*Grapholitha nebritana*).

The **Crescent Pea Moth** (*Grapholitha dorsana*).

Moth: Somewhat larger than the preceding species. Fore wings olive brown, with many small short white lines on the front margin. A yellowish-white crescent on the middle of the hinder margin. Hind wings brownish. *Caterpillar:* Nearly $\frac{2}{5}$ inch long, 16-legged, orange yellow, with brown or black head, neck-shield, last body segment, and thoracic feet. Covered with brownish-yellow warts. *Habits:* The moths fly about in large numbers round the pea blossoms, always a short time after sunset. The female lays one, two, or at most three eggs, on a very young pod, or on an ovary. In fourteen days the caterpillar is hatched, bores into the pod, and attacks the peas. The opening made in the margin of the pod closes up again. The pod generally ripens early. When it opens, the full-grown caterpillars creep out,

and become pupæ in the soil, within a web, where the pupa lives through the winter. The peas attacked are always covered, while in the pod, with the coarse-grained excrement of the caterpillars, and are often united two or three together by web fibres. *Remedy:* Deep digging of the soil before the winter, or, still better, deep hoeing as soon as the pea crop is gathered in. In this way many of the caterpillars or pupæ hidden in the soil will be destroyed.

Family: **Tineidæ** (*Leaf-miners*).

These moths are the smallest of the Lepidoptera. Like the snout moths, they have strongly developed labial palps, but are distinguished from them by their small wings; the hind wings are especially small, and have sharp tips. The extent of the wings is increased by a broad marginal fringe. When at rest, the wings slope like a roof, and the fringe near their tips is often turned upwards. Antennæ thread-like, tolerably long—in the males of a few species may even be very long. Caterpillars slightly hairy, with five, or, rarely, four pairs of pro-legs. To this family belong the well-known **Clothes Moth**; the **Corn Moth**, living in stored-up grain; and also—

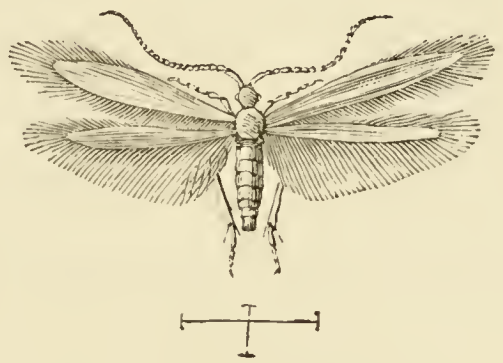

Fig. 106.—The Larch Moth (*Coleophora laricella*).

The **Carrot Moth** (*Depressaria nervosa* = *Hæmylis daucella*).

Moth: Length $\frac{2}{5}$ inch. Span of wings rather over $\frac{4}{5}$ inch. Fore wings reddish-grey brown, blackish on the nerves, and with scattered whitish markings. Hind wings more of a grey brown. Thorax and abdomen very shiny, and somewhat brighter than the

wings. *Caterpillar:* Nearly $\frac{2}{5}$ inch long, tolerably thick, especially in the middle, and variegated. Head, thorax, and last body segment shining black, the last two regions with reddish-yellow margin, and the thorax, in addition to this, divided into right and left halves by a longitudinal yellow line. The rest of the body is olive green; a broad orange-coloured line divides it into a darker dorsal and a lighter ventral side. On the back many ill-defined warts of a shining black colour. *Habits:* In March and April many of the carrot moths which have survived the winter come out of their hiding-places; they only fly at night. The eggs are laid separately on umbelliferous weeds, carraway, or carrot plants. The caterpillars are first seen when the plants flower; they live on the flower-stalks, which they bind together by a few threads, and devour the flowers and young fruits, sometimes even the flower-stalks. The caterpillars are very active, and let themselves down by a thread when disturbed. Usually they are fully grown in five weeks, and then bore into the stalks of the plant, where they become pupæ. It is not known whether there are one or two generations. The caterpillars are found at very various times, from May to August.

The **Diamond-back Moth** (*Plutella cruciferarum* = *Tinea xylostella*).

Moth: About $\frac{1}{4}$ inch long; span of wings $\frac{3}{5}$ inch. Fore wings small, lancet-shaped, with long fringes. Ground colour yellowish brown, darkly speckled. Hind wings brownish grey, small, strongly fringed. When at rest the long fringes form a sharp backward and upwardly directed comb, while the antennæ are applied together and stretched straight forwards. *Caterpillar:* About $\frac{1}{4}$ inch long, tapering in front and behind. A beautiful green, with a black head. Lives hidden under a very thin web or under a few fibres,

on the lower side of the leaves of cabbage, rape, and other crucifers. *Habits:* The pupa lives through the winter; the moths emerge in May, and fly about in the evening. Two generations; the first generation of caterpillars in the first half of July, the second in late summer. The second generation is particularly apt to be destructive to cabbage. Pupæ found on the leaves of the plants attacked, and surrounded by a thick web.

Sixth Order: **Hemiptera** (Half-winged Insects).

The mouth parts are modified into a sucking and piercing beak. Head small. Legs usually slender, with two- or three-jointed feet. Wings are absent in several species (*e.g.* bed bugs); in one section (*e.g.* fruit bugs) the fore wings are half of leathery, half of membranous texture (Fig. 107); in others, all four wings are membranous (winged plant lice), or the fore wings are somewhat harder than the hind wings (frog-hoppers). Incomplete metamorphosis (p. 89). None of agricultural importance except—

Fig. 107.—Left pair of wings of a Bug.

Family: **Aphidæ** (*Plant Lice*).

Long, five- to seven-jointed antennæ. Long thin legs, no power of springing. Sucking beak long and thin. In the same species there are both winged and wingless aphides, mostly the latter. In autumn, male and female specimens are found. After pairing, the latter lay their eggs, which are destined to live through the winter. The aphides hatched from these the following spring are all females, but are distinguished from those of the previous autumn by producing living young, which contain at the time of their birth the germs of a new generation. The number of young produced by a single female, and the number of

generations appearing within the year, vary according to the species. There are species in which each female bears from eighty to one hundred young, and nine to sixteen generations succeed one another in the year. In autumn males and egg-laying females once more appear. As a rule the eggs live through the winter, but the insects themselves may also do this. I must add that there are constant differences within the boundaries of the same species according to the habitat, and especially in the species which regularly wander, either from one plant to another, or from the leaves to the roots. But since the species injurious to agriculture do not migrate in this way, nothing further need be said on the point. As aphides suck plant juices during the whole of their lives, and have enormous reproductive powers, they are very destructive. They suck from stems and leaves the juices which would otherwise be used by the plants themselves for growth or for the production of flowers and fruit, and bear young, which bore their beaks into the same part in the immediate neighbourhood of their mother, and quickly begin to multiply in their turn. In this way, colonies consisting of a hundred or more individuals are regularly formed (*e.g.* on peas, beans, roses). A plant part attacked in this way shrivels for want of nourishment, and the aphides upon it would die if they did not wander elsewhere. The third generation usually contains, not only wingless individuals, but also others

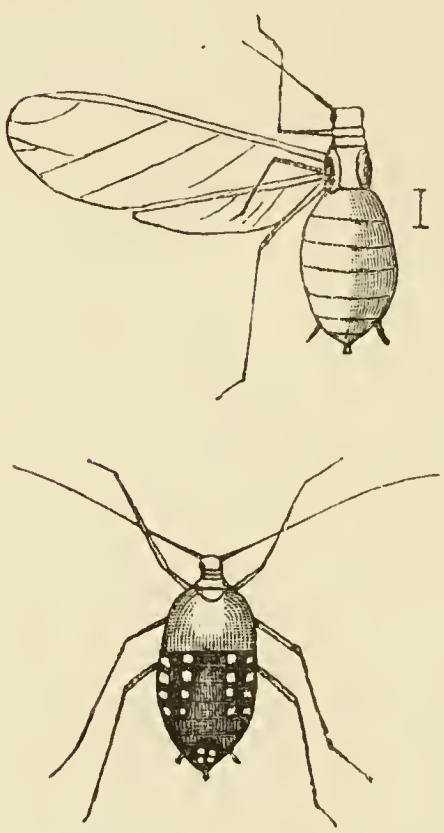

FIG. 108.—The Bean Aphis (*Aphis papaveris*); a larva of the same below.

which, after repeated moults, fly away and start a new colony in another plant. Since aphides have many enemies (starlings, sparrows, grasshopper warblers, etc., lady-birds and their larvæ, drone fly larvæ, lace fly larvæ), and are often killed in large numbers by wind and rain, it only occasionally happens, particularly in dry summers, that they entirely or largely destroy the plants they infest. They injure plants, not only by drawing away their nourishment, but also by the separation of a sugary sticky fluid from the anus. If the minute drops of this fluid fall from the upper parts of an infested plant to the lower (garden and field beans), or from the leaves of an infested tree to the plants growing at its foot, or, as sometimes happens, are carried by the wind to more distant plants, great damage may be caused. The fluid evaporates and leaves behind a shining sticky substance, which closes up the stomata of the leaves, and partially checks exchange of gases (assimilation and respiration). Particles of dust, sand, and smoke carried by the wind, and also the cast skins of the aphides, stick to the surface of the leaves and render exchange of gases still more difficult. The leaves develop brown dirty patches, and die off. Besides this, the spores of disease-producing fungi, carried by the wind, stick very easily to the places covered by the sweet fluid, and readily germinate in it. Aphides may thus be the indirect cause of several diseases (*e.g.* smut). These insects are destructive, therefore, to other plants than those infested by them. *Remedies:* Spraying with any one of the fluids destructive to them—soapy water; a decoction of quassia chips; tobacco water, not too concentrated; Nessler's fluid ($1\frac{1}{2}$ ozs. soft soap, $2\frac{1}{4}$ ozs. tobacco mixture, 2 ozs. fusel alcohol, half a pint ordinary alcohol, diluted with rain water up to a quart: when used, mix with one-fifth the quantity of rain water); Koch's fluid (2 lbs. soft soap dissolved

in half a gallon of hot water; ½ lb. of quassia chips extracted for twelve hours in 5 quarts of rain water, and the fluid thus obtained boiled and filtered. It is then added to the soap water, and the whole brought up to 10 gallons by addition of rain water). Spraying with one of the above-named fluids must be renewed in a short time, so as to reach all the aphides wherever possible; if even a few remain untouched, there will soon be a large number again. A warm evening is best for the spraying. Infested plants can also be strewn with finely powdered substances, or these may be scattered over them by means of a small bellows. Since such substances should remain on as long as possible, they should be used after rain or early in the morning, when the dew is still on the leaves. Among powdered matters suitable for the purpose, the following may be named: gypsum, lime, tobacco, wood-ash, insect powder (prepared from the flower-heads of Persian species of chrysanthemum and from tansy heads). It must also be pointed out, that these remedies must be employed as soon as the insects begin to show themselves in considerable numbers; it is not desirable to delay till the infestation has made considerable headway, as it is then much more difficult to get a satisfactory result. In some cases, it is desirable to cut off and burn or otherwise destroy much infested parts, or those parts on which the insects first begin to multiply (*e.g.* early cutting off of the tips of the stems in field and garden beans).

The species of aphis which most commonly occur upon cultivated plants are:—The **Bean Aphis** (*Aphis papaveris*), $\frac{1}{12}$ inch, black; on the tips of the stems of field and marsh beans, also on poppy, turnips, lettuce, and on several wild composites and umbellifers. The **Pea Aphis** (*Aphis ulmariæ*), $\frac{1}{8}$ to $\frac{1}{6}$ of an inch long; green; July to September on peas, chickling peas, and several wild leguminous plants; very destructive. The **Corn Aphis** (*Aphis cerealis*), $\frac{1}{12}$ inch,

green or reddish brown, also reddish brown with green abdomen; June to August on rye, barley, oats and several grasses; sucks the axis of the ears, and the flower-stalks; as the (black) eggs remain on the stubble during the winter, it is advisable to plough this deeply in immediately after harvest. The **Oat Aphis** (*Aphis avenæ*), $\frac{1}{12}$ inch, dark green, speckled with white; on oats and barley, scarcely ever on the ears, but on the leaf-sheaths and the upper sides of the rolled-up leaves. The **Hop Aphis** (*Aphis humuli*), $\frac{1}{12}$ inch, green; on the under side of the hop leaves, and, when very abundant, on the scales of the fruit. The **Cabbage Aphis** (*Aphis brassicæ*), $\frac{1}{12}$ inch, dark green, speckled with grey; from May to September on all kinds of cabbage, and also on other crucifers.

Seventh Order: **Physopoda** (Bladder-footed Insects).

Very minute insects, possessing a characteristic jaw apparatus, with which they pierce the outer skin of leaves or the parts of flowers, and suck their juices. The four small wings have long fringes at their edges; the fore wings are tolerably hard. The ends of the feet do not possess claws, but small bladders or suckers. The metamorphosis is incomplete. In some years, one or other of the species may increase to a very large extent, and these minute insects then fly about in swarms, especially on very hot days; and they also wander about in large flocks. If they settle on the face or hands of human beings, they cause a disagreeable and persistent itching, as they continually walk about.

Fig. 109.—Corn Thrips (*Thrips cerealium*).

The **Corn Thrips** (*Thrips cerealium*), $\frac{1}{12}$ inch. Dark

brown to black. Male wingless. Female with small wings bending outwards at their tips (Fig. 109); fore wings horny, hind wings membranous. Larva orange yellow; head, prothorax, and tip of the abdomen, black. After the last moult it becomes yellowish white, and acquires scale-like wings. Hybernates in the adult condition; lays its eggs on various grasses, also on different grain plants. The larvæ, and, later on, the perfect insects are found in large numbers sucking the ovaries of flowering corn (wheat, rye, barley); as a result of which the ears do not fully develop, but wither away. *Remedy:* Deep ploughing of the stubble, by which the hybernating individuals are destroyed.

The **Elder Thrips** (*Thrips sambuci*) lives in elder, and sometimes also multiplies in very young field beans, the leaves of which blacken and shrivel up in consequence.

The **Flax Thrips** (*Thrips lini*) often injures flax.

Eighth Order: **Diptera** (Flies).

Mouth parts elongated, adapted for sucking or piercing. Fore wings developed, rarely absent. Hind wings absent, as such,—altered into club-like bodies (balancers or halteres) often covered with scales. Metamorphosis complete. Larvæ always legless; most have biting mouth parts and no distinct head (maggots); the head-bearing dipterous larvæ possess similar mouth parts. The last become obtectate pupæ (p. 93), while the headless larvæ become pupæ within the larval skin.

Family: **Culicinæ** (*Gnats*).

Slenderly built, with long, thin legs. An elongated piercing proboscis in the female. The male with feebly developed mouth parts, and feather-like antennæ. Both sexes suck up water and plant juices, and the female blood as well; hence only the latter bites, especially at night. They hybernate in the adult

condition in cellars, barns, etc. The female lays 250 to 300 eggs on any floating object in stagnant water (pools, ditches, water-vessels). The larvæ (with large head, well-developed prothorax, and a breathing-tube on the abdomen) live in water, as do the pupæ. Several generations annually; especially in damp summers and districts where the draining of the soil leaves much to be desired. Although sand-flies torment our domestic animals more than gnats, yet these also may be very troublesome to them. They principally attack the less hairy parts of the body (inner side of the ears, nose, mouth, corners of the eye, arms, sexual parts). *Remedies:* Thorough draining of the soil. Washing the domestic animals to be protected with a vinegar extract of walnut leaves; rubbing with walnut-leaves. Wherever possible, any sores should be covered up, as they attract gnats, sand-flies, and flies; or the skin near them may be painted with turpentine or very dilute carbolic acid. This is the less to be neglected, as several kinds of flies eagerly lay their eggs in the sores of domestic animals.

Family: **Gallicolæ** (*Gall Gnats*).

Small gnats with large broad wings, much narrowed at the root, rounded at the tip, and generally rough with hairs. Feelers made up of a large number of spherical or cylindrical joints, covered with spreading hairs. Proboscis short, legs long. The female has an ovipositor, with which she inserts eggs in any part of a plant. At this particular spot

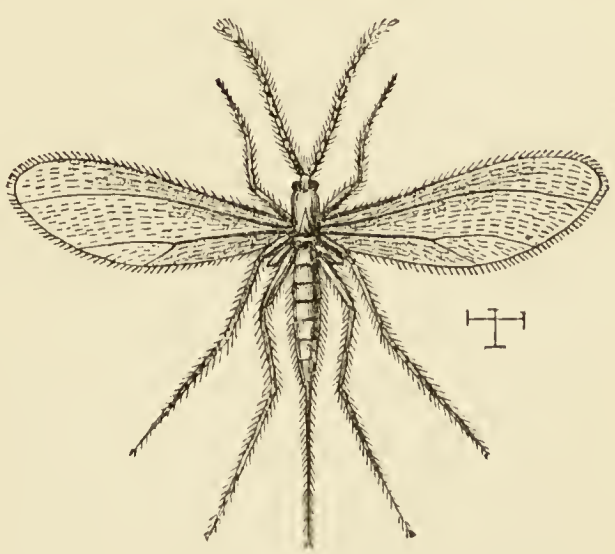

Fig. 110.—The Wheat Midge (*Cecidomyia tritici*), female.

a luxuriant growth of vegetable tissue takes place later on, of varying extent, and even forming a regular gall. The species of gall gnat are usually brightly coloured, often red or yellow; these colours are lost, however, in dried specimens. The larvæ are spindle-shaped, yellowish white, yellow, or red; they become pupæ either in the soil or within the part of the plant which they inhabit. Several species are destructive to fruit-tree culture or forestry; I mention here only the most destructive kinds which attack cultivated plants.

The **Hessian Fly** (*Cecidomyia destructor*).

Female about one-eighth of an inch long, male somewhat smaller. The former velvety black, with black hairs, red belly, and red markings; wings greyish; antennæ one-third the length of the body. Male black, with reddish-yellow hairs, dirty red belly, and red markings. The name "Hessian flies" was given in North America, during last century, because it was believed they were introduced from Germany, in 1778, by Hessian soldiers, in their straw. It is still very destructive in North America, also in Germany, Russia, England, and Scotland. *Habits:* During April or May, on warm still evenings, the female lays her eighty or ninety eggs, singly or in pairs, on the lowest leaves of the still very short haulms of rye, wheat, and barley. Eight days, on an average, after this the maggots, which are at first oblong and spotted with reddish yellow, are hatched, and glide down into the leaf-sheath, where they begin to suck the haulm. They gradually alter their shape, becoming ovoid, and transparent with the exception of the large yellowish-white, quite opaque fat body. They soon become pupæ (Fig. 111), which look like grains of linseed, and are found in summer on the haulms of the ripe grain. The presence of the constantly sucking larvæ causes great and injurious

distortions of the plant, especially obvious during the flowering time, and for a short time afterwards. The haulm withers, and shrivels at the point where the larvæ are present, *i.e.* above the lowest node, or the lowest but one. At the time when the haulm begins to turn yellow—that is, when the grain begins to ripen,—the larvæ become pupæ; the haulm now easily breaks off at the infected spot; a strong wind or heavy rain throws it to the ground. A badly infested field looks, on this account, as if a herd of cattle had got loose and trodden it all down, or as if the grain had been devastated by hail. Only a few haulms bear ears containing normally developed grains. The flies emerge from the pupæ in August and September, after which the females quickly seek the winter corn, and lay their eggs singly or in pairs on the leaves of the yet young plants. The larvæ creep between the leaf-sheath and the still quite undeveloped haulm, and, in the case of small haulms, a number of larvæ may collect together in the immediate neighbourhood of the root, causing a spherical swelling. In many cases the plant dies if its lower parts are inhabited by many larvæ. Before winter, the larvæ attain their

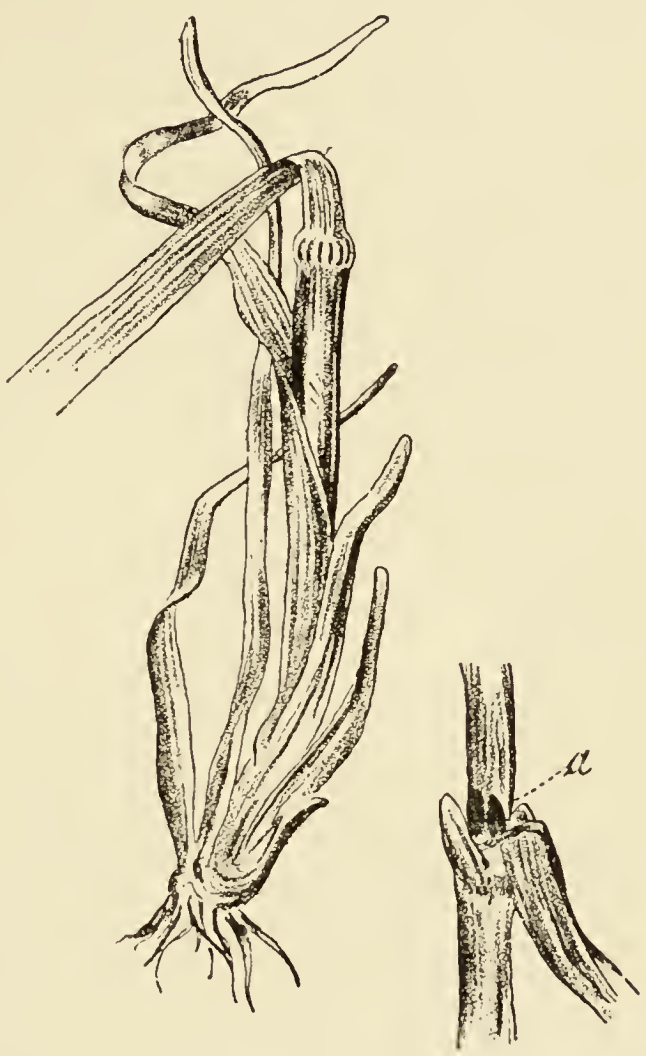

FIG. 111.—Plant of Barley, attacked by Hessian Fly. The pupæ at *a*.

full size, leave the plants, and creep into the soil, where, in the following spring, they become pupæ, from which flies emerge fourteen days later. There are, therefore, two generations annually. The *spreading* of Hessian flies into regions where they were formerly unknown may be caused by (*a*) straw containing the linseed-like pupæ (straw for paper manufacture, packing, etc.); (*b*) grain, among which are often found pupæ that have fallen out of the haulms among the separated grain. *Remedies:* 1. Sowing the winter grain as late as possible, so that the females of the summer generation when they come out of the pupæ will find no winter-grain plants in which to lay their eggs. 2. Ploughing up the stubble immediately after harvest, or else burning it, so that the pupæ found above the lower nodes are either deeply buried or else burnt.

The **Scarlet Wheat Midge** (*Cecidomyia equestris*).

Female about $\frac{1}{8}$ inch, male $\frac{1}{12}$ inch; cherry red, with yellow hairs; back of the thorax dark brown. Antennæ as long as the body in the male, half as long in the female. On the wing from May till June; lays its eggs on the leaves of grain plants, at the base of the uppermost leaf by preference. The blood-red maggots, when they are hatched, let themselves slide down, and get between the leaf-sheath and haulm. Here they work themselves into the haulm, making a longitudinal groove, the walls of which swell more or less, and the end of which is indicated by an obvious transverse thickening. The leaf-sheath hiding the attacked part of the stem is usually more or less swollen. These gall-like outgrowths take up a great deal of nutritious matter, not only from the affected haulm but also from the plant at large, so that the regions not directly attacked are retarded in their growth. The larvæ are full grown

at harvest time, leave their hiding-places, and let themselves fall to the ground, where the following spring they become pupæ, from which midges quickly emerge. *Remedy:* After a year in which the insect has caused great damage, the fields must be deeply ploughed in order to kill the larvæ, which would otherwise live through the winter.

The **Wheat Midge** (*Cecidomyia tritici*).

Male $\frac{1}{25}$ inch, female (Fig. 110) $\frac{1}{17}$ inch, and possessing an ovipositor which, when extended, is twice that

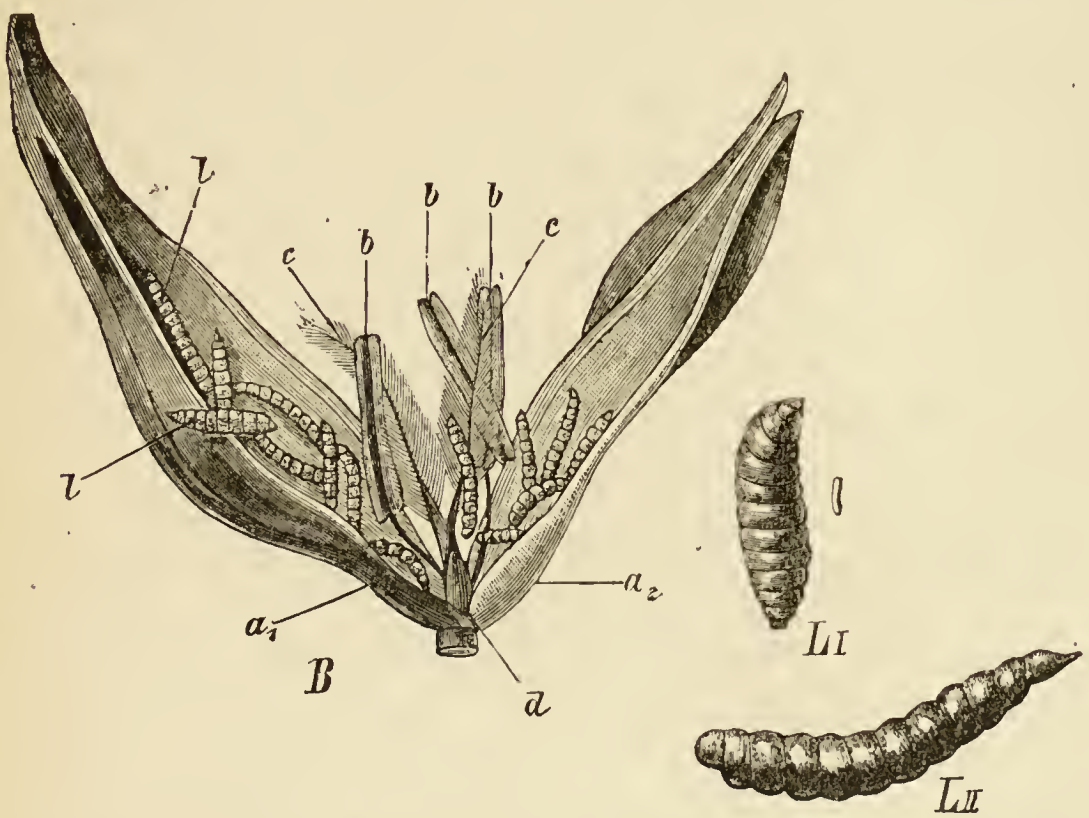

FIG. 112.—The Wheat Midge (*Cecidomyia tritici*): LI larva in the contracted, LII, the same in the extended condition. B, a wheat flower: a_1 outer, a_2 inner glume, *b*, stamens; *c*, brush-like stigmas; *d*, ovary; *l*, larvæ of the wheat midge. LI and LII highly, B less highly, magnified.

length. Citron yellow, slightly hairy; antennæ blackish, eyes black, legs dirty yellow. In spring or early summer, the midges creep out of the soil in fields where wheat has been planted the previous year. After pairing, the females wander to fields where wheat or, more rarely, rye is growing. The

attacks of the midges commence when the ears begin to emerge from the leaf-sheaths, and are continued throughout the flowering time of the wheat. At night the female pierces the glumes with her ovipositor, and lays three to ten perfectly transparent eggs in each flower. Each midge lays eggs in several flowers, but two or more midges may use the same flower for this purpose, so that as many as thirty maggots may be found in one bloom (Fig. 112). The maggots, which are hatched out in a week, creep down to the ovary and suck its juices. If many maggots live in one flower it is sure to die, but if there are only a few it may produce a grain, though this may be small. Ears infested by the maggots develop yellow spots later on; many ears remain quite empty, and consequently thin and upright. Full-grown maggot: $\frac{1}{8}$ inch; straw yellow to chrome yellow; quite transparent when very young. Is fully developed in three weeks, and then lets itself fall to the ground (July or August). Becomes a pupa the following spring; fourteen days later the midge escapes.

Family: **Rostratæ** (*Crane Flies, Daddy Longlegs*).

These very long-legged gnats live on the juices of plants, and do not sting. The larvæ are legless, without a hard well-marked head; those of most species live in mouldering plant parts (*e.g.* rotten wood), or the decaying manures of our fields and meadows. A few species, however, are very destructive, since they injure roots and other parts of cultivated plants. The adult and larval stages of all the injurious kinds are not yet distinguished. We know that the larvæ of the yellow and spotted *Tipula maculosa* are chiefly destructive in sandy soil; while more binding clay soil and rich garden earth are infested by the larvæ of *Tipula oleracea* (Fig. 113), and damp meadows by

those of *Tipula paludosa*. The two last-named species are very much like one another; grey or greyish brown with bright brown wings, having dark front margin. Much is still unknown about the habits of "crane flies"; my researches relate to the **Yellow-spotted Crane Fly** (*Tipula maculosa*). The adults fly about in swarms during summer, usually from the beginning of June, in the fields where the larvæ lived in spring. They lay their eggs either in the same fields or (usually) in others, and are blown

FIG. 113.—The Daddy Longlegs, or Common Crane Fly (*Tipula oleracea*). Left, the male and the maggot; right, the female and the pupa.

about for long distances by the wind. Where the flies settle they lay each time two or three black ovoid eggs, bent like a sickle, and repeat this till all the eggs (200 to 250) are laid. Those fields which have previously been grass land are the most infested by the crane flies. The larvæ are headless, grey to lead coloured, with small prickles at the hinder end of the body, and they first appear, in large numbers, under the pieces of turf which are left behind in such fields, and which appear to be the centres from which

the destruction of the standing corn begins. The larvæ are hatched out in summer, during the later part of which, and during autumn, they devour plant roots; after hybernating, they again attack the underground parts of plants the following spring. They devour most readily the roots of grass and corn, but also those of clover, rape, and several other plants, including some found in flower and kitchen gardens. They are mainly injurious either in autumn or spring, according to the nature of the plants attacked. Young grain plants are killed by them, older ones usually not. On fields where winter corn grows they therefore do most damage in autumn, while this is the case in spring on land where summer corn is cultivated. They are sometimes harmless, since they can also feed on roots left behind in the ground. The larva do not limit their ravages to underground parts; in the evening, and also in the daytime during dark damp weather, they devour parts of the first leaves of very young corn plants, though the damage thus effected is often inconsiderable. In May the larva is ready to pass into the pupa stage; it comes near the surface and becomes a brown pupa, bearing small spines on the abdominal rings. After a rest of fourteen to seventeen days, the pupa works its way upward till the front part of its body sticks out of the soil. The fly then escapes. *Enemies:* Mole, shrews, wagtails, grasshopper warbler, rook, gulls. *Remedies:* When the maggots are very destructive in gardens they may be collected, preferably in wet weather, since they then leave the soil during the day. If they appear to an injurious extent on summer corn, the fields should be rolled in April (either with the ordinary or the spiked roller). At the time (June) when the crane flies swarm about the fields and meadows in flocks, thousands of individuals can easily be caught with a net.

Family : **Muscæformes** (*Gnat Flies*).

Gnats with relatively short legs, and antennæ which are in any case shorter than the body, and are usually quite short and cylindrical, possessing, however, six or more joints, while the antennæ of true flies usually have only three joints. The gnat flies form, as it were, the transition between the slender gnats with their long legs and antennæ, and the more thickset flies, the legs and antennæ of which are short. Here belong the genera of **Shade Gnats** (*Sciara*, e.g. *Sciara Thomæ*, the larvæ of which often wander about in companies, as the so-called **Army Worm**), the **Sand Flies** (*Simulia*), and the **Hair Gnats** (*Bibio, e.g.* the **Garden Hair Gnat**, *Bibio hortulanus*, the larva of which gnaws the roots of plants, especially in humous garden soil).

The **Sand Flies**, or **Mosquitoes** (*Simulia*),

have thick-set bodies, short legs, and short nine or ten-jointed antennæ; they are from $\frac{1}{25}$ to $\frac{1}{5}$ of an inch long, and have a short but sharp proboscis, with which they suck up the flower juices which constitute their chief food. But the female also sucks the blood of human beings and animals, making herself exceedingly annoying in this way. Its larval state is passed through in stagnant water; its appearance is therefore local, and is especially favoured by damp summers. The mature sand flies are found from early spring or through the whole summer; several generations succeed one another in the same year. Sand flies often appear in swarms, containing thousands of individuals. Since the female eagerly creeps into the ears, noses, and corners of the eyes in horses and oxen, she is extremely annoying and even dangerous. Her bite produces a smarting sensation, and may cause actual boils to form in the skin. When a large

swarm of sand flies settles on a herd of cattle or on some horses, these animals become maddened and furious; they often rush wildly round for so long that they fall down dead. *Simulia reptans* is a common British form. *Remedies:* Compare what is said on p. 165, about gnats. Sand flies can usually be kept from horses' ears by means of ear-caps.

Family: **Tabanidæ** (*Gad Flies*).

Large or medium-sized flies with thickset body, large broad head, flat abdomen, and strong legs. The proboscis is less developed in the male, which lives merely on plant juices, than in the blood-sucking female. The cylindrical whitish larvæ live in earth, and are harmless. But the female insects bite human beings, and the larger kind attack horses and cattle in such a manner that blood-drops may be seen on the ground under the animals attacked, if these remain for a time in the same spot. There belong to this family: 1. The **Breeze Flies** (*Tabanus*), large insects up to $\frac{4}{5}$ inch long, which are seen flying about with a buzzing sound over meadows and fields in the sunshine (**Ox Fly** = *T. bovinus;* **Horse Fly** = *T. autumnalis*). 2. The **Lesser Breeze Flies** (*Hæmatopota*), smaller and more slender, with grey wings, bite most before a storm and in hot sultry days. 3. The **Blinding Breeze Flies** (*Chrysops*), as large as the Lesser Breeze Flies, but broader, with shining golden-green eyes and wings marked with black. *Remedies:* Compare p. 165, and above; draining the soil, however, is no good here.

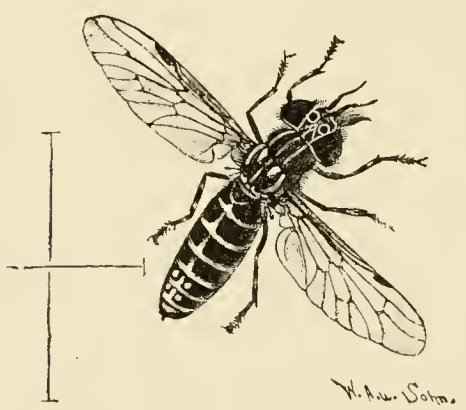

FIG. 114.—The Rain Breeze Fly (*Hæmatopota pluvialis*).

Family : **Muscidæ** (*True Flies*).

These are flies with three-jointed antennæ, constructed on the type seen in the common house fly. Here are included the **Caterpillar Flies** (*Tachina*), the **Flesh Flies** (*Sarcophaga*), **Common Flies** (*Musca*), **Flower Flies** (*Anthomyia*), **Green-eyed Flies** (*Chlorops*), etc.

The **Caterpillar Flies** (*Tachina*)

are black, grey, or reddish yellow flies, reminding one by their appearance of the common house fly or the blue-bottle. They play the same part in the economy of nature as the sand wasps (p. 129), but always lay their eggs externally on the skin of the host ; the maggots consequently never prey on those insect larvæ which live in the tissues of plants or in the soil.

Fig. 115.—Caterpillar Fly (*Tachina fera*).

The **Flesh Flies** (*Sarcophaga*)

have a longish abdomen, with large bristles on the hinder margins of the segments. Thorax with three longitudinal streaks. The flies suck up sweat, but do not bite. The eggs develop within the abdomen of the mother ; the flies lay the young larvæ in dead flesh ; also, if not kept clean, in wounds of human beings and animals,—sometimes, too, in the genital opening of horses, cattle, and swine, in which case the maggots live as true parasites in the vagina and uterus, causing a secretion of mucus, upon which they live. Two to three generations yearly ; fifty to eighty maggots each time. *Remedies :* On keeping the flies from cattle, cf. p. 165 ; to keep them from meat, fly-nets, a gauze cover. **Blow Fly** (*S. carnaria*), with black speckled abdomen.

The **Common Flies** (*Musca*)

are coloured dark or shining green. The headless white maggots live in dung (**House Fly** = *Musca domestica*), in fresh or decaying meat (**Blue-bottle** = *M. vomitoria*), exceptionally (*M. vomitoria*) in wounds that are not kept clean, or in the vagina of several domestic animals. *Remedy:* Compare above ("Flesh Fly").

The **Flower Flies** (*Anthomyia*).

These are found on flowers, and resemble many common flies in appearance and colour. The headless white maggots live in dung, also in decaying or sound parts of plants; a few species may sometimes develop in the one kind of material, sometimes in the other. *Anthomyia meteorica* swarms round the heads of domestic animals, and may even cause inflammation of the eyes and ears. The **Wheat Bulb Fly** (*Anthomyia coarctata*, about a quarter of an inch long, yellowish grey, with black hairs) lives as a larva during winter and spring in the hearts of rye and wheat plants, the leaves of which become yellow in consequence. During April and the beginning of May the larvæ quit these plants and become pupæ in the ground. The second generation can, in like manner, live in various kinds of summer grain. The **Lupine Fly** (*A. funesta*)—nearly one-fifth of an inch long, brownish grey (male) or whitish grey (female), with black legs—digs, when a larva, tunnels in the roots, stems, and seed-leaves of young lupine plants, causing the root and stem to turn black, and the seed-leaves to wither. *Preventive Measure:* Early sowing of the lupines. The **Mangold and Beet Fly** (*A. betæ*), a quarter of an inch long, yellowish grey, lays its eggs, five to eight in number, in the young leaves of mangold and beet. The maggots devour the green substance of the leaf between the two layers of epidermis, so that

the leaves die. In June the maggots creep out of the leaves, and become pupæ in the soil. The flies quickly escape, and two or three generations follow one another in the year. As, however, the leaves are now larger, the later generations only effect a small amount of damage. *Preventive Measure:* Close sowing of the turnips, so that even if many are killed there will still be enough young plants. The **Cabbage Root-eating Fly** (*A. radicum*) and the **Radish Fly** (*A. floralis*) live as fleshy, wrinkled, dirty white maggots with black dots, in the underground parts of turnip, cabbage, horseradish, radishes, etc. They lead a similar life to the **Cabbage Fly** (*A. brassicæ*), the cylindrical, smooth, yellowish-white maggot of which lives in the underground parts of cabbage, turnip, and rape. The roots attacked swell here and there (Fig. 116), and later on decay; the leaves of the infested plants first become of a dull leaden colour and then wither. Entire fields of cabbage, rape, or turnips, are often destroyed by cabbage fly maggots. The insect passes the winter in the pupa state; the flies appear early in the spring, and usually twice more later on. It is therefore most desirable to pull up and burn the infested plants as soon as possible. A proper rotation of crops should also be practised. [The **Onion Fly** (*A. ceparum*) maggot feeds within the bulbs of stored onions. The male fly is grey, the female yellow.]

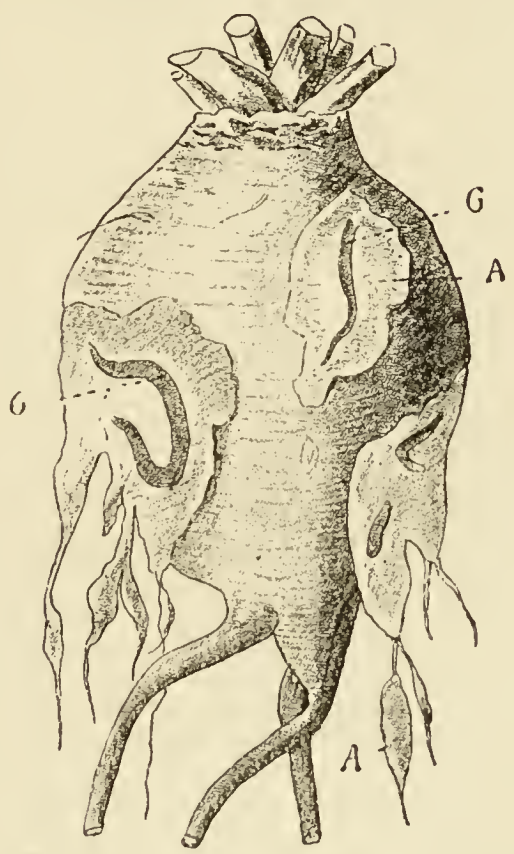

FIG. 116.—A turnip infested by the Cabbage Fly: A, swellings; G, tunnels.

The **Cheese Fly** (*Piophila casei*),

one-fifth of an inch long, slender, with a metallic sheen, almost hairless, black, with dirty yellow legs and wings of glassy clearness. These small flies abound in front of the windows of places where cheese is stored; in summer and autumn the shining white maggots, which are cylindrical in form with tapering ends, and one-third of an inch long, live in large numbers in old cheese, gnawing it through and through, and making it dirty. Now and then they spring forwards by bending their bodies into a circle and suddenly straightening them again. They become pupæ on the walls or in straw, near the cheeses from which they have crept out. *Remedies:* Keeping the cheeses clean; mechanical exclusion (gauze screens outside the windows, enclosure in chests).

The **Green-eyed Flies** (*Chlorops*)

include a number of small flies, under one-sixth of an inch long, with spherical head, rounded greenish eyes, strongly arched thorax, and short egg-shaped abdomen, pointed in the male and blunt in the female. The headless larvæ live in the haulms of grasses and species of grain; the life-history of a few forms only is adequately known. A few are harmful, especially as there are two or three generations annually. The late summer generation often appears in large numbers, indeed in actual swarms. Since no species lives exclusively on corn, it is impossible to keep them down for a long period of time. I describe only two species:—

The **Ribbon-footed Corn Fly** or **Yellow Haulm Fly** (*Chlorops tæniopus*),

nearly one-sixth of an inch long, shining yellow; the antennæ are black, and there are three longitudinal

stripes on the dorsal side of the thorax and four transverse bands on the abdomen of the same colour; the latter region is scarcely longer than the thorax. The insect (Fig. 117) is on the wing in corn-fields about the middle of May. It lays its eggs separately on the upper leaves of various species of wheat, rye, and barley, choosing the upper side of the blade, not far from the sheath. Only those plants are selected for the purpose in which the ears are still hidden deep down between the leaf-sheaths. Wheat plants are picked out whenever possible. The maggot when hatched works its way between leaf-sheath and haulm, digging into the latter. It is yellowish white, clear and translucent, and about a quarter of an inch long. While still young it penetrates the haulm, and then attacks the developing ear or the upper part of the haulm which immediately adjoins this, and travels gradually up to the first node of the haulm or nearly so, always continuing to slowly suck. Thus a furrow, from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches long (Fig. 118, C and D), is formed along the surface of the upper part of the haulm, and often also along the lower part of the ear. The part of the haulm attacked swells transversely, and the part below often remains short, so that the ear cannot emerge from the leaf-sheath; but, in any case, only small worthless grains are developed. The furrow is always much deeper below than above, and its margins thicken in consequence of the swelling of the tissues of the haulm. At the end of June or in July, the larva becomes a pupa at the lower end of the furrow. The yellowish-brown pupa (Fig. 118, B), one-fifth of an inch long, remains as such in the furrow for three weeks; the fly

Fig. 117.—The Ribbon-footed Corn Fly (*Chlorops tæniopus*).

emerges in August. Very considerable damage may be done by the first generation, of which the habits have just been described. During 1869 in Silesia, from two-thirds to five-sixths of the ears in many fields remained hidden in the leaf-sheaths, and consequently gave no increase. The first generation of the ribbon-footed corn fly can also develop in the way described in the haulms of several grasses, *e.g.* in species of *Poa* and *Holcus*.

The flies, emerging in late summer, lay their eggs, here, too, separately, on the leaves of grass or corn. Wherever possible, they seek out for the purpose the winter wheat plants then present in the fields, but also content themselves with rye, or even with wild or meadow grasses; they have to be satisfied with grasses if, at the time of egg-laying, the winter corn is not yet up. The maggot, when hatched, works its way to the inner side of the leaf-sheath, and thence to the apex of the still very small haulm; there it remains during the winter. The damage becomes apparent the following spring. The growth in length of the haulm in question is extremely small, while growth in thickness increases to an abnormal extent. Almost all the leaves completely surround the haulm, which swells to an enormous extent (Fig. 119), together with the enclosing leaf-sheaths, which are much broader than usual. The unattacked plants are naturally much larger than the sickly ones, and deprive these of air and light, so that they die down, being overshadowed, not only by the sound haulms, but also by their own secondary shoots. The resulting damage may be tolerably great, especially at the edges of the field. It may happen that both summer and winter generations of the ribbon-footed corn fly are harmful in the same district; but it frequently happens that only one or the other is complained of in a particular spot. It is only natural that the flies, which swarm around in May, and again in August,

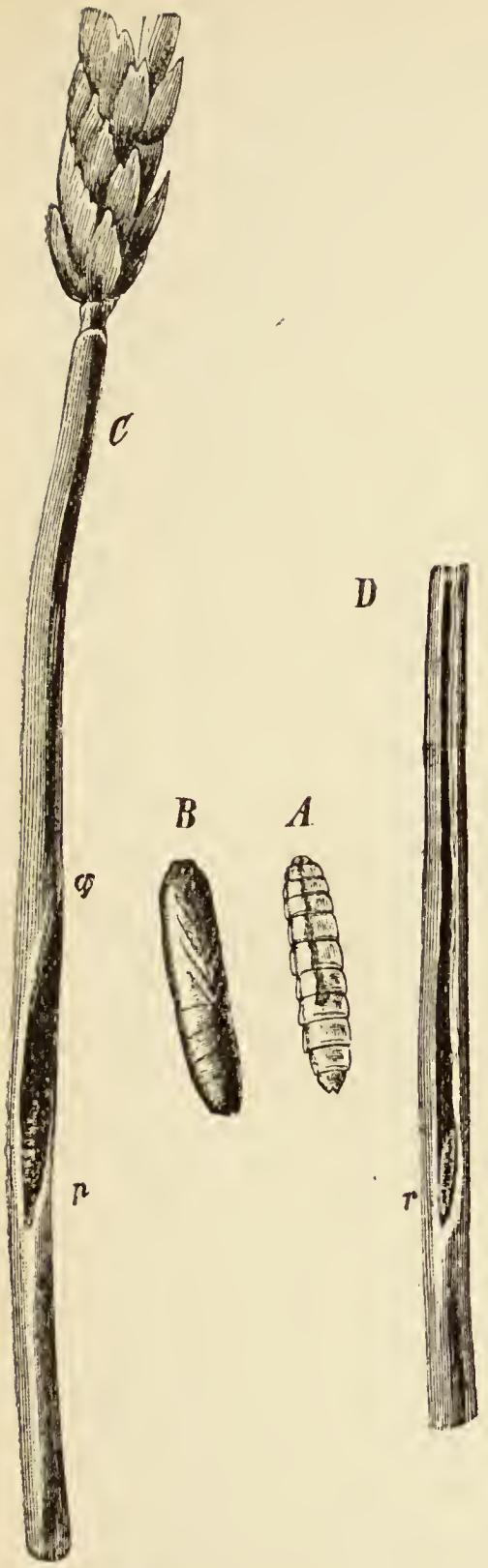

FIG. 118.

Fig. 118.—The Ribbon-footed Corn Fly (*Chlorops tæniopus*): larva (A) and pupa (B) magnified. To the left a wheat haulm and ear (C) with the furrow (*q*) dug out by the larva; the pupa (*p*) is seen at the bottom of the furrow. To the right a wheat haulm with furrow (D) and the larva (*r*) lying in it.

Fig. 119.—A wheat plant distorted by the winter generation of the Ribbon-footed Corn Fly.

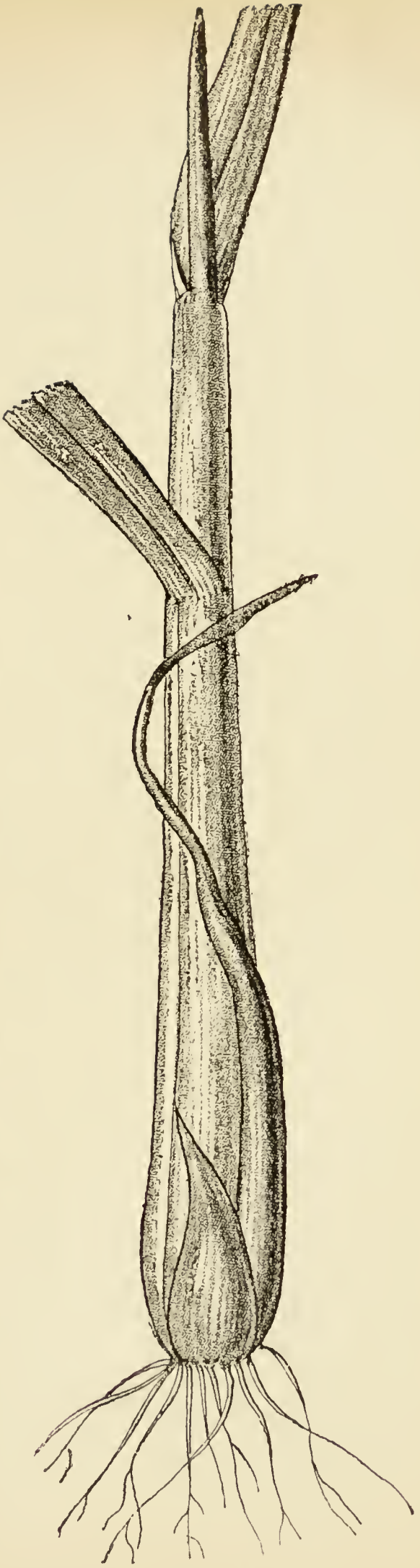

FIG. 119.

September, or October, should not always find suitable corn plants upon which to deposit their eggs. In such cases grasses are used. *Remedies:* Sowing the summer corn as early as possible, that it may be developed to a stage which is unsuitable for the purpose of egg-laying, before the flies appear. The winter seed, however, must be sown as late as possible, so that the second generation of flies may find no corn plants fit to lay their eggs upon. Bearded wheat, especially the strongest varieties, should be sown in preference to awnless wheat. Careful tillage and suitable manuring, so that strong plants of rapid growth may be produced.

The **Frit Fly** (*Chlorops*, or *Oscinis frit*)

(Fig. 120, C) is about one-tenth of an inch long, shining black, with a metallic sheen. Legs short, feet yellow. Maggot (Fig. 120, A) yellowish white, about one-eighth of an inch long, cylindrical, and tapering in front. Usually three generations. 1. The maggots of the first generation are found during May, in the lower part of the haulm of summer corn (especially oats and barley); the plants attacked either die off entirely, or some haulms develop further, remaining small, however, and yielding only a few light grains. The base of the haulm thickens abnormally, but the growth in length is always small; the leaves, too, grow badly, first becoming yellowish at the tip, and then entirely yellow or reddish. The symptoms of disease are exhibited to a less or greater extent, according as few or many (even up to ten) maggots inhabit the base of a plant. The shining brown pupæ (Fig. 120, B) are found in the lower part of the haulm, or between the leaf-sheath and the haulm (Fig. 120, D). The adult insect is on the wing at the end of May and in June. The first generation often appear on wild or meadow grasses, and are chiefly seen on summer corn when this is sown late or develops slowly.

FIG. 120.—The Frit Fly (*Oscinis frit*, L.): A, larva; B, pupa; C, fly; D, a diseased corn plant, as appearing in spring,—the larvæ and pupæ are seen of the natural size in the lower part of the plant.

2. The maggots of the second generation are found in average cases during July, on the as yet scarcely ripe grains of late summer corn, principally those of oats and barley, often occurring also in the haulms of grasses. They keep between the awns, and suck the juices of the soft developing grains, which are rendered incapable of growth, and in any case remain light. The maggots of the second generation develop more quickly than those of the first or third; they are mature in three weeks. The pupa rest is very short, and the flies appear in August, September, or October. They lay their eggs on the leaves of winter corn or winter grasses, and from these eggs are developed (3) the maggots of the third generation, which are to be found, during September and October, in the heart of winter corn and grasses, injuring these plants in exactly the same way that the maggots of the first generation injure the summer corn. The insect passes the winter as a pupa in winter corn plants or grasses. It is but very rarely that all *three* generations infest the corn of any particular region; as a rule, only the first, second, or third generations do this, or the first *and* third; in such cases the other generations live on grasses. *Remedies:* Extermination of the insect is impossible, since it can always go from corn to grass plants. Oats and barley are almost always attacked in spring, if in the immediate neighbourhood there is winter rye inhabited by the maggots, for the flies, when they emerge the next spring, seek out the summer corn. This may, however, be made impossible, or at least difficult, if a field of peas, clover, lupines, rape, or some other crop not of gramineous nature, is interposed between fields of winter corn and those of oats, barley, or similar late sown crops of summer corn. Sowing the summer corn (especially oats and barley) as early as possible.

Family: **Syrphidæ** (*Hover* or *Hawk Flies*).

Chiefly includes brightly coloured flies, marked with yellow or red and black bands or patches (Fig. 67), and flying rapidly with a buzzing noise. They can remain suspended at the same point in the air by moving their wings up and down with great rapidity. A few of them resemble the humblebee in their thick covering of hair; others, with yellow and black abdomen, look like wasps (*Syrphus*). The proboscis is adapted for sucking, but not for piercing; these flies suck their food from flowers. They are fond of hovering in the air in sunny places. The legless larvæ vary, according to species, in their habits, and consequently in their structure. Some (those of the **Drone Flies,** *Eristalis*) live in stagnant water; others (*e.g.* those of *Eumerus lunulatus*) live in onions, which they hollow out; while some, again, develop in rotten wood, etc. The maggots of the **Aphis-eating Flies** (*Syrphus*), however, feed on insects, chiefly aphides, which they suck out completely. They are elongated, tapering in front, thickened behind, move like leeches, and vary much in colour (green, yellow, brown, chequered), according to the species. As they grow quickly, and consequently more than one generation is found each year, and as they are very voracious, we must look upon them as powerful allies for the extermination of aphides.

Family: **Stomoxydæ** (*Stable Flies*).

In many points the stable flies resemble ordinary flies, but their mouths are adapted for piercing. Their painful bites make them known to every one as pests to human beings and cattle. Here belongs the common **Stable Fly** (*Stomoxys calcitrans*), a form often confounded with the house fly, but distinguished from it by a sharp proboscis projecting at right angles, besides which the abdomen is more of a yellowish

grey. The maggots usually live in dung. Two generations yearly: the first flies about in March; the second, and much more numerous one, in August and September. *Remedies:* Cp. p. 165.

Family: **Œstridæ** (*Bot Flies*).

Medium-sized or large flies (Fig. 121), with thick hemispherical heads, and mouth-parts not strongly developed. The antennæ can be drawn back into deep pits. The bot flies make a buzzing sound during flight. The headless, twelve-ringed maggots live in the bodies of various mammals. Their skin is provided with numerous wart-like projections, or circlets of spines. When very young the maggots are elongated and cylindrical, and then possess a mouth-hook, which disappears during the later moults. As soon as the maggots are fully developed they leave the body of the animal they inhabit, and let themselves fall to the ground, where they become pupæ within the shrivelled larval skin.

The following genera are distinguished: **Warble Flies** (*Hypoderma*), and **Bot Flies** (*Œstrus* and *Gastrus*, or *Gastrophilus*). To the first-named genus belongs the

Ox Warble-fly, or **Ox Bot Fly** (*Hypoderma bovis*),

two-fifths of an inch long, black. Hair: whitish yellow on the head; reddish yellow on the fore part of the thorax, black on the hinder part; grey on the fore part of the abdomen, black in the middle, and reddish yellow behind. Legs black. Wings brownish, not quite transparent.

On the wing during summer (June to September). As soon as the cattle hear the flies buzzing around (especially on hot days) they become very restless, run about as if mad, and even plunge down steep places. Young cattle are selected for egg-laying;

the elongated white eggs are fixed separately to hairs. The maggot, elongated when first hatched, perforates the skin, and gets into the subcutaneous connective tissue, where it does not, as a rule, keep to any one place, but wanders here and there, sometimes penetrating the flesh, or even entering the spinal canal. It always, however, wanders back again later on into the subcutaneous connective tissue, where it gives rise, during the winter or the following spring, to one of the well-known tumours, or "warbles." After fixing on a definite spot, it moults, becoming broader, and of a yellowish-white colour. The maggot first causes an increased flow of blood to the part, and then inflammation. An excavation filled with matter is thus developed, and there is gradually formed a connective tissue sac communicating with the exterior by a minute tube. In spring, or early summer, the warble, which is visible externally, has reached the size of a pigeon's egg; the maggot meanwhile becomes first greyish yellow, then brown patches appear, and lastly it assumes a dark brown colour, is an inch long or rather more, and somewhat swollen. It is now ready to pass into the resting stage, crawls out, and lets itself fall to the ground, where, within the larval skin, it becomes a black pupa four-fifths of an inch long, from which, about four weeks later, the fly creeps out. *Damage done:* If the warbles occur only in small numbers on an animal, its health is not much affected, though this must undoubtedly be the case if there are many, say fifty, or even up to a hundred, in the same animal. In such cases the yield of milk will be considerably diminished. Holes, too, are present in the skin, which, though they may close again, if the animal remains alive, always leave a thin place. The outer surface of meat from animals infested with warbles is dirty yellow, flaccid, or even soft and jelly-like ("licked beef"); it must be scraped off. *Enemies:* Starlings settle, in spring, on the backs of infested

cattle, and seize the parasites with their beaks. Starlings, rooks, and wagtails destroy the maggots ready to become pupæ, as they lie on the ground. *Remedies:* Washing the back, shoulders, and loins with vinegar extract of walnut leaves during the summer, to keep away the bot flies. In spring: squeezing out the maggots from the warbles, having previously opened them, when necessary, with a penknife. If the warble is "ripe," *i.e.* if it has opened so far that the black hinder end of the maggot can be seen, the opening may be stopped with fat or cart-grease, by which the larva will be killed where it lies.

The **Sheep Bot Fly** (*Œstrus ovis*),

two-fifths to three-quarters of an inch long, yellowish grey, almost hairless; head large, round, reddish; thorax grey, with small black warts; abdomen yellowish white; legs short, bright; wings of a glassy clearness. The flies are found (in September) on the walls of sheep-folds, and in woods near which sheep graze. On sunny days the female flies round the sheep, in order to deposit her brood upon them. The sheep threatened press their nostrils to the ground, though this is not of much use. The maggots are hatched while still in the body of their mother, and are deposited by her on the margins of the nostrils. These little maggots creep about on the mucous membrane lining the internal cavities of the nose, causing intolerable itching. The sheep try to get rid of the intruders by shaking their heads and rubbing their noses on the ground. The maggots, however, creep further into the nasal cavities, and get into the hollows of the frontal bone and upper jaw, perhaps even into the horns. In these places they feed on the fluid which their presence causes the mucous membrane to give out in large quantities. The maggots remain as such for nine months, during

which time they alter their shape in various ways. Those just born are white, one-twenty-fifth of an inch long, while those which have reached the length of two-fifths of an inch are yellowish white. Individuals ready to become pupæ are about an inch long, yellowish brown, with dark transverse lines; they wander back to the nasal cavities and thence to the exterior, often being expelled by sneezing. In the soil they become pupæ, first of a brown, then of a black colour, within the larval skin; the flies emerge in six or seven weeks. Different maggots develop at different rates, according to the nature of the cavities into which they penetrate.

The maggots cause the disease known as "false gid," which appears most obviously from March to May; at this time the parasites are tolerably well developed. They irritate the mucous membrane of the cavities of the head in which they live, causing an unusually large flow of blood to these parts, as a result of which the mucus secreted in the nose increases largely in quantity (sneezing, snuffling), and the brain begins to work abnormally (uneasy movements of the head, high lifting of the feet; in worse cases, rolling of the eyes, gnashing of the teeth, and foaming at the mouth). The sheep have also an intolerable itching of the nose, which they rub in consequence on the ground, against posts, or their own legs; besides this, there may be inflammation of the eyelids and increased secretion of tears. They are also apt to grow very thin. The disease is more frequent, and the symptoms severer, in young than in old sheep. False gid may cause death; the animal is cured, however, after the maggots have crept out. *Preventive Measures:* Keeping the sheep away from the edges of woods, avenues, etc., where the flies live by preference. When sheep are killed, the maggots coming from the head should be collected and destroyed. Smearing the margins of the nostrils with tar, or rubbing them with walnut

leaves, before the sheep go to pasture in the morning. For sheep, which in late summer rub their noses up and down tree-stems, walls, hedges, or their own legs, substances that cause sneezing may be employed, *e.g.* cheap snuff, which is best introduced into the nose by means of a quill-feather. Later on, when the maggots have passed from the nasal cavities into the frontal sinuses, etc., sneezing does no good. Operations seldom succeed in removing all the maggots.

The **Bot Flies** (*Gastrus*, or *Gastrophilus*) live in various parts of the stomach (in left side of horse's

FIG. 121.—Horse Bot Fly (*Gastrus equi*): *a*, egg on a hair, strongly magnified; *c*, younger (magnified), and *b*, older larva; *d*, opened pupa-case; *e*, fly.

stomach) and intestine. I give, first of all, a compressed tabular view of the external characters and mode of life of the four British species. (See next page.)

Diseases caused by Bot Flies.—The maggots bore into the walls of the stomach and intestines until they reach the layer in which the blood-vessels, lacteals, and lymphatics ramify; they then suck the juices found in these vessels, and also serous fluids. In small numbers they are often almost harmless, but when a great many are present they hinder the secretion of the digestive juices. They may also set up inflammation of the intestinal coats, or may cause death by internal bleeding if they perforate the wall of an artery. In foals they often bore right through the wall of the intestine, and enter the abdominal cavity, where they may set up inflammation of the peritoneum or of the mesentery. There may be as

Species.	Fly.	Egg.	Maggot.
Horse Bot (*Gastrus equi*).	½ to ⅔ inch, very hairy, like a humblebee; brownish yellow. Fore part of thorax with yellowish-brown, hind half with black hairs. Abdomen with brown hair in front, brownish-yellow behind.	White: on the hairs of the mane, neck, chest, fore legs, and hind feet of horse.	At first flesh-red, then yellowish-brown. Lives in the stomach of the horse, often in large numbers.
Cattle Bot (*Gastrus pecorum.*)	Male about ½ inch, brown, closely covered with a mixture of yellowish and black hairs. Wings smoke-coloured. Female rather larger. Head, thorax, and first segment of the abdomen with colour and hairs as in the male; rest of abdomen black, and tapering posteriorly. Wings smoke-coloured.	Black: on the same parts of the horse's body as in the preceding species; exceptionally on the hairs of horned stock.	First yellowish grey, then blood-red. First in the small intestine, and, for some time during June or July, in the rectum of the horse. When ready to become pupæ, they creep out of the anus, to the margin of which, however, they may remain sticking for some time.
Red-tailed Bot (*Gastrus hæmorrhoidalis*).	About ⅔ inch. Fore part of thorax dark fawn colour, with bright yellow fur-like hair; hinder part black. Abdomen shining black, with yellowish-white hair in front, black in the middle, and orange-yellow at the tip. Wings of glassy clearness, with dark brown veins.	Black: on the lips and margins of the nostrils in the horse.	First red, then bluish green. To begin with, in the cavities of the nose or mouth, in the horse, very soon in the stomach or small intestine, remaining there several months; then, a few months longer, in the rectum. Exceptionally, the maggots remain in the gullet for some time.
Nose Bot (*Gastrus nasalus*).	Nearly ½ inch (not including the long ovipositor of the female). A fine but close covering of hairs; variegated, not always evenly covered with hair, especially not on the black abdomen (partly white, black, orange-yellow, yellowish grey); thorax a shining blackish brown, covered with fine, golden-yellow hair. Wings clear as glass, widely spread when at rest.	White: on the lips and margins of the nostrils in the horse.	Yellowish white. In the first part of the horse's small intestine, near the aperture of the stomach; exceptionally in the nasal cavities, gullet, and stomach.

many as a hundred or two hundred maggots in the stomach or intestine, and they then cause, at the very least, digestive disturbances and colic. If the maggots (*G. nasalis*) get into the windpipe (or larynx) they interfere with the breathing; if into the gullet, with swallowing. In either case death may ensue (winter, early spring). *Remedies:* Killing the flies as they lay their eggs. Removing the eggs by brushing, combing, and washing; the last is best done with warm water, to which some caustic potash is added. Rubbing the lips and nostrils, neck, chest, and fore legs with walnut leaves, or a decoction of the same.

Family: **Pupipara** (*Louse Flies*).

Body flat and broad; skin leathery and tough. Fore legs curved, adapted for climbing among the hairs. Some (*e.g.* the Forest Fly) have a pair of wings, others (the Sheep Louse Fly) are wingless. They bring forth living maggots, each time one only, which is ready to become a pupa immediately. They reproduce several times. Here belong: 1. The **Forest Fly, Spider Fly,** or **Flat Fly** (*Hippobosca equina*), about one-third of an inch long, brown, with broad abdomen, and two broad stumpy wings. Occurs in summer and early autumn, chiefly on horses, especially near the anus, on the belly, and on the flanks. It sucks blood, and irritates by running about on the body. Seldom flies. 2. The **Sheep Louse Fly,** wrongly called "sheep louse" and "sheep tick" (*Melophagus ovinus*); about one-fifth of an inch long, wingless, rusty yellow, with brown abdomen, very hairy. Climb slowly about among the wool of the sheep, and suck blood. Their excrement may colour the wool green. Lambs especially are much hindered in their growth by this fly. The fleece is also damaged, for the itching set up by the insect forces the animal to rub itself against things so that the wool gets pulled out. The flies are

chiefly found on meadow sheep; but relatively few in winter. The parasites leave the body of their host for the purpose of reproduction, and lay their maggots, which at the time of birth are nearly one-sixth of an inch long, under little bits of earth or heaps of dung. When sheep are kept in folds no permanent result can consequently be expected from the use of any remedy if, at the same time, the fold and all its contents are not kept clean. The walls must be cleansed, and washed with caustic potash, to which carbolic acid has been added. *Curative Washes:* A decoction of walnut leaves and vinegar. Turpentine, soapsuds, decoction of tobacco. Washes containing arsenious acid (*e.g.* Bigg's Improved Sheep and Lamb Dipping Composition) must be used with caution; unpalatable substances may be added, so that the sheep will not lick them, or else a muzzle may be employed.

Ninth Order: **Aphaniptera** (Fleas).

Body strongly compressed laterally. Head small. Mouth-parts adapted for sucking and biting. Legs long, especially the last pair. They possess the power of springing. Wingless. Complete metamorphosis. Larva worm-like, legless, hard-headed. The **Dog Flea** (*Pulex serraticeps*), which only occasionally passes on to human beings, lives on dogs and cats. *Remedy:* Sprinkling the moistened hair with Persian insect powder or powdered parsley seed.

Tenth Order: **Parasita** (Lice).

Body flattened. Legs adapted for climbing among hairs and feathers, as the last joint of the foot is hook-shaped, and can be bent back against the preceding joint; a hair can thus be held fast between the two joints. Eyes absent or ill-developed (simple). Wingless. The eggs ("nits") are fastened by the mother louse to the hairs of the host; the young lice resemble

the old ones in almost all particulars; there is no true metamorphosis. All lice have a kind of proboscis, which can be protruded and retracted, and upon which are placed the mouth-parts, which enable it to be used for sucking or biting. According to the last feature a distinction can be drawn between true or blood-sucking lice and biting lice or fur-eaters, which devour small scales derived from the skin or else bits of hair and feathers. Lice multiply very rapidly on the bodies of human beings and animals when insufficiently cleansed, and under these circumstances more on sick and ill-nourished individuals than on those which are healthy and well nourished. It is obvious that the true, blood-sucking lice usually injure their host more than the biting lice, which, however, especially when present in large numbers, may cause an intolerable and injurious itching by their movements here and there. *Preventive Measures:* Suitable feeding and treatment. Proper care of the skin. *Remedies:* Repeated combing with a comb which has been dipped into a solution of soda. Rubbing the badly infested spots with soft soap and soda, washing them out after twenty-four hours. Among other washes are—6 parts soft soap, 1 part benzine, 10 to 15 parts water; or tobacco water, 1 part of common tobacco in 20 to 25 parts water; arsenious acid, in various mixtures, *e.g.* in Bigg's Composition (p. 193). Employ the muzzle.

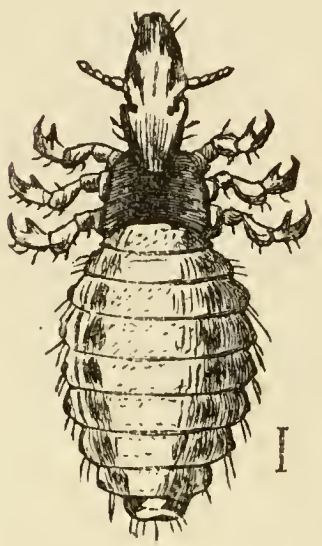

FIG. 122.—Horse Louse (*Hæmatopinus macrocephalus*), magnified ten times.

CLASS II.: **MYRIOPODA** (CENTIPEDES AND MILLIPEDES).

Respiration by tracheæ, as in insects. The body consists of a head and a large number of very similar segments, each of which possesses limbs. One pair of antennæ.

This class is divided into two orders: (1) that of **Centipedes** (*Chilopoda*), with mouth-parts adapted for seizing prey, and *one* pair of legs to each segment; (2) that of **Millipedes** (*Chilognatha*), adapted for devouring substances resembling humus, also the parts of plants; and *two* pairs of legs to each segment. Here belong, above all, the **Snake Millipedes** (*Julus*) or "False Wireworms" (Fig. 123), of which several species eat out germinating seeds (peas, beans, mangolds, and beet), and also attack juicy plant parts (potatoes, turnips, carrots). Seedlings may be protected by using potatoes to draw away the millipedes.

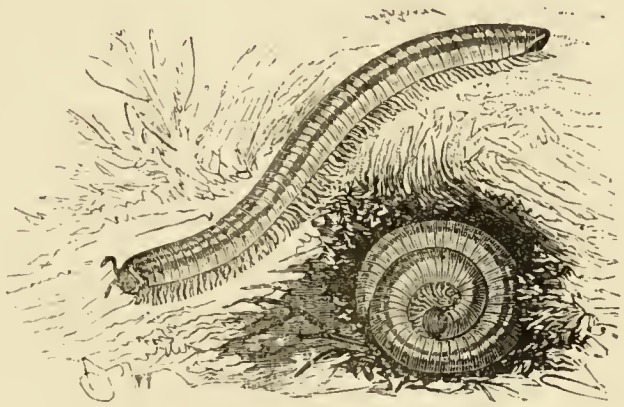

Fig. 123.—Common Snake Millipede (*Julus terrestris*), somewhat magnified.

CLASS III.: **ARACHNOIDEA** (SCORPIONS, SPIDERS, MITES).

Air-breathing (by ordinary or modified tracheæ); the lower forms breathe with the skin. Body at most consists of two chief regions, since head and thorax are always fused together, making up a cephalothorax (Fig. 124); but this may again be united with the always unsegmented abdomen into a single piece

(Fig. 127). The last is the case with the mites, in which, therefore, the characters of segmented animals can only be recognized in the limbs. In the true spiders (Fig. 124) the body consists of cephalothorax and abdomen. Arachnids have always four pairs of legs, which, in the true spiders, are attached to the cephalothorax, in the mites to the front part of the unsegmented body.

Fig. 124.—A Spider (*Salticus scenicus*).

The chief Orders belonging here are: (1) true **Spiders** (*Araneida*); (2) **Scorpions** (*Scorpionida*); (3) **Harvestmen** (*Opilionida*); (4) **Mites** (*Acaridea*). Only the last contains species of importance agriculturally.

Order: **Acaridea** (Mites).

Small arachnids, in which the cephalothorax and abdomen are fused together into one piece (Fig. 127). The just-hatched young have three pairs of legs, the adults, of course, four.

Family: **Acaridæ** (*True Mites*).

Soft skin. No tracheæ, no eyes. Legs short, often with a sucker at the end. Here belong the **Cheese Mite** (*Acarus siro*), the **Meal Mite** (*Tyroglyphus farinæ*), and several other species living in dead organic substances; also—

The **Itch**, or **Mange Mites**.

These live as parasites on or in the epidermis, and cause the *itch* or *mange* (scabies) in man, as well as in several domestic animals. By means of the structure and habits three genera are distinguished:—

1. Digging, blood-sucking mange-mites living in the skin (*Sarcoptes*);

2. Blood-sucking mange-mites living on the outer surface (*Dermatocoptes*);

3. Mange-mites which merely devour scales of the epidermis (*Dermatophagus*).

It is obvious that sarcoptic scabies is not so easily cured in the same host as the dermatocoptic scabies, since the mites causing the former dig their passages

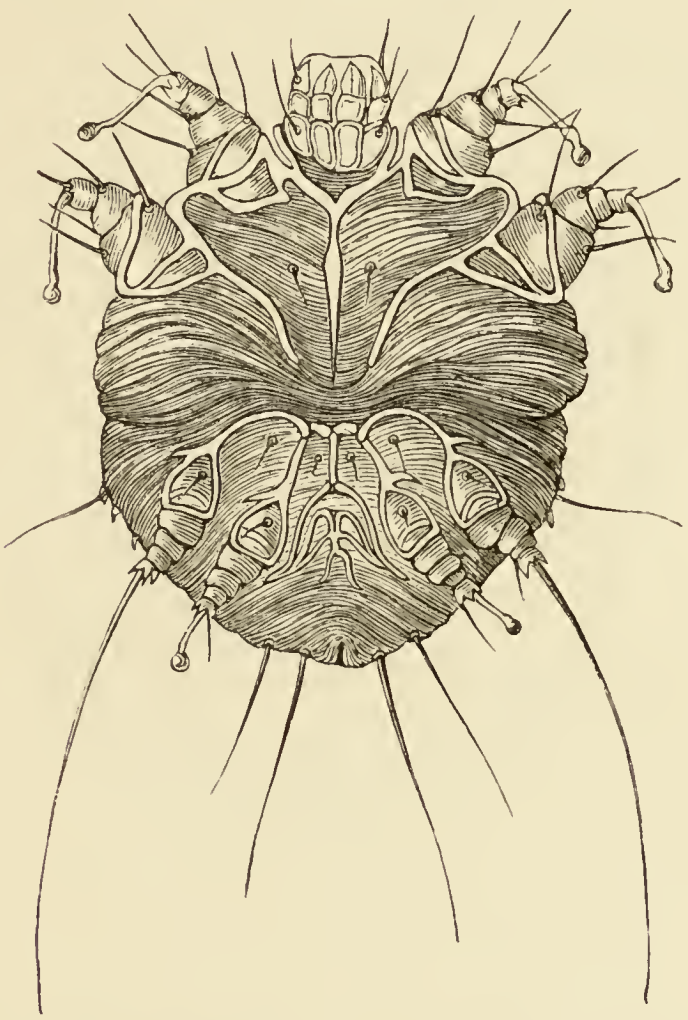

FIG. 125.—Mange Mite of the Pig (*Sarcoptes scabiei*, var. *suis*), seen from the ventral side.

into the epidermis, while those causing the latter at least remain on the surface. Dermatophagic scabies is most easily got rid of, since the mites which cause it not only remain on the outer surface of the skin, but also, instead of holding fast, run about here and there; it is easily understood that this kind of mange can often be removed by simple brushing.

The itch, or mange (scabies), is caused by the irritation which the mites continually exert on the skin. The warmer the surroundings of the host, the more active the mites, and the more painful the skin

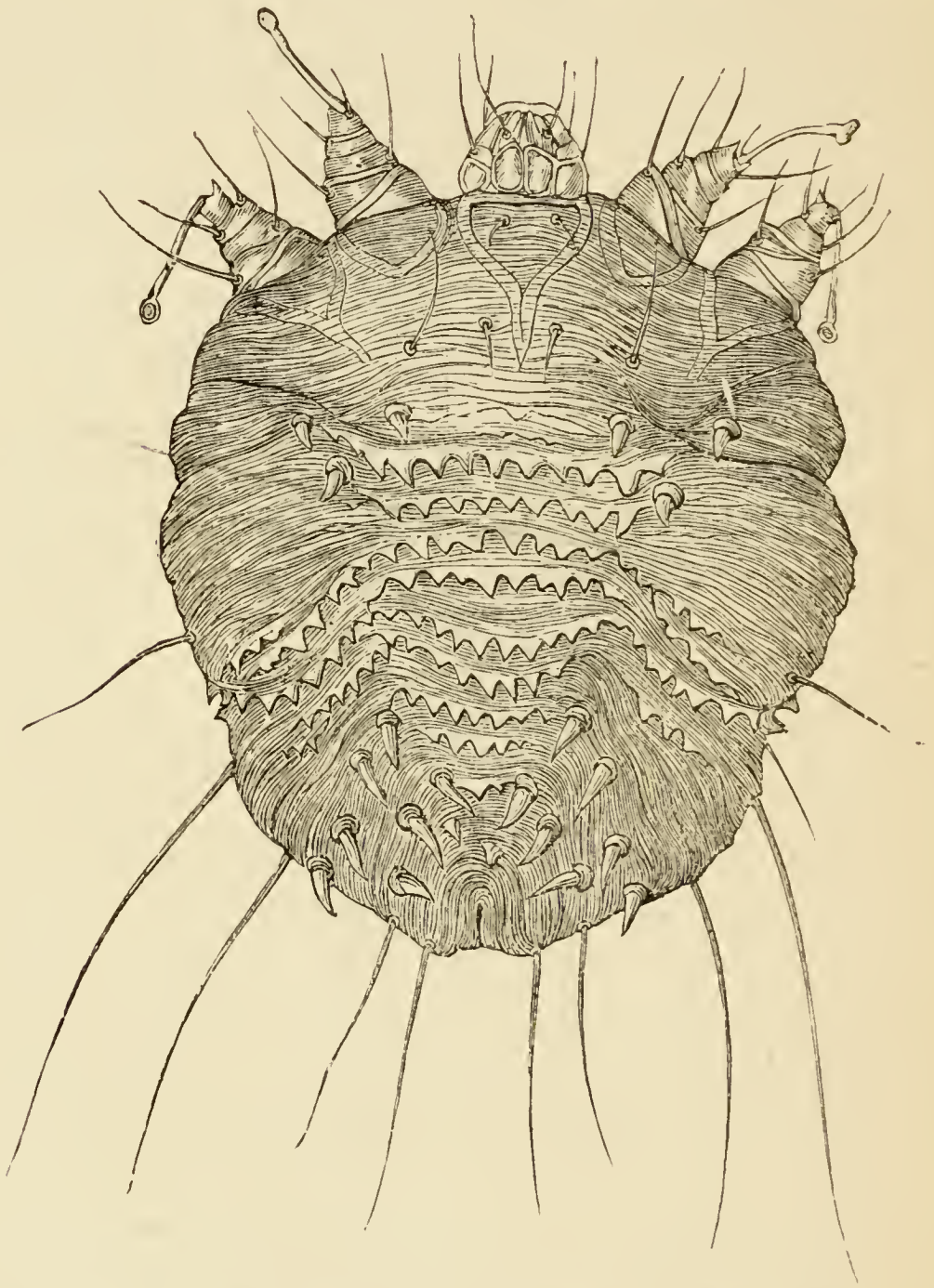

FIG. 126.—Mange Mite of the Pig (*Sarcoptes scabiei*, var. *suis*), seen from the dorsal surface. × 200.

disease. (The scarcoptes mites, *e.g.*, are most unendurable in man when in bed, and scabby sheep are most tormented when in a warm fold.) The mites

multiply with such enormous rapidity that it is easy to understand how a single fertilized female, transferred to a new host by contact with an affected animal, is able, in a short time, to make large patches of the skin mangy. The course of the disease is generally as follows:—Soon after infection small swellings appear, which become little bladders of the size of a pin's head. These burst, and the affected parts of the skin are quickly covered with a crust formed from shrivelled bits of skin and dried-up fluid. In many places the attacked parts of the skin are moist, for the host, in consequence of the severe itching, rubs or knocks itself. In consequence of the shedding of fluid the hairs stick together, and later on fall out. The skin thickens, becomes encrusted, and is thrown into folds, between which there are deep cracks. Among domesticated animals the sheep is certainly the one which suffers most from scabies (*Dermatocoptes*), especially as the disease spreads rapidly in the warm sheltering fleece, which also makes the removal of the parasites a matter of the greatest difficulty. The wool gets dry and brittle in the diseased parts, and its fibres become loose, though they remain attached for a short time, since their tips are glued together by the sticky substance which exudes from the little thickenings in the skin. They gradually fall out, however, leaving the skin covered with a thick brownish crust, looking as if it were soaked with oil. Badly infested sheep get thin and even die. This, however, is not usually the case, and the injury consists in the great deterioration of the wool, both as regards quantity and quality.

The following summarizes the kinds of scabies affecting man and domestic animals, and indicates how far one kind of host can affect another:—

Itch of **Man** (*Sarcoptes*) can be caught by the dog, but by no other domestic animal.

Scabies of the **Horse**.—The sarcoptes mange of this

animal is contagious for man, and for the ox, but no other domestic animal. The dermatocoptes mange (found more particularly on the inner sides of the legs, and on the genital organs, tail, and mane) does not spread to man or to other domestic animals. Nor is this the case with the dermatophagus mange of the horse (on the fetlocks and adjacent parts of the legs).

Scabies of the **Ox**.—The dermatocoptes mange of the ox (chiefly affecting the sides of the neck and root of the tail) spreads to men and horses, but not to sheep. The dermatophagus mange (principally on the root of the tail and near the anus) does not seem to be transmitted to man, horse, pig, or dog.

Scabies of the **Sheep**.—The dermatocoptes mange of sheep is not transmitted as a permanent disease to man, nor to other domestic animals (with the exception of the goat). The sarcoptes mange of the sheep (chiefly on the head) causes the itch in man.

Scabies of the **Pig** (*Sarcoptes*) is contagious for the dog, and causes an eruption in man.

Scabies of the **Dog** (*Sarcoptes*) can be caught by man, pig, and horse.

Scabies of the **Cat** (*Sarcoptes*) is contagious for man, horse, ox, dog, and rabbit.

Scabies of the **Rabbit** (*Sarcoptes*) is contagious for man, but this is not so with the dermatocoptes mange, which flourishes in the external passage of the ear in the rabbit.

Scabies of the **Fowl** (*Sarcoptes*), which affects the legs of hens, causing thickening of the skin and formation of large spongy crusts, may infect horses. Hen-houses should not be built in stables.

Remedies.—From the foregoing facts relating to the transmission of scabies from one host to another, the preventive measures at once follow: A mangy animal must not be allowed to come into contact either with another animal of the same kind or with an animal of any other kind for which the disease in

question is contagious. If scabies appears in a few members of a flock or herd, it is absolutely necessary to separate the healthy animals from the sick ones,—and it is further necessary to cleanse and disinfect places where mangy animals have been kept, as well as implements or machines which they have touched, before sound animals are brought near such things. Cleansing of folds, etc., with hot water, followed by six weeks' disuse. Cleansing of infected implements with hot soda and water. The first important thing to ascertain is whether a sick animal, which has the external symptoms of scabies, is really affected; in order to determine this the mange-mites must be found. If the mites cannot be found on the suspected animal, it must be brought into a warm stall and covered over; especial care must be taken to warm the places where the skin seems worst attacked; warmth makes the mites more active, and induces them to come to the surface. Sarcoptic mites are the worst. I will deal but briefly with the treatment of mangy animals, as it is usually best to obtain the advice of a veterinary surgeon. *External* applications must naturally be employed. It appears from the investigations of *Vogel* that corrosive sublimate and arsenic kill the mange-mites less rapidly and therefore less surely than creosote, carbolic acid, benzine, tar, caustic potash, and tobacco, or even soft soap. *Zürn* recommends a thorough smearing of soft soap on the parts affected. The soap is allowed to remain for some time, even for a whole day, the infested spots are then rubbed with hot water, and brushed, if possible, until the crust on the skin disappears. Other remedies may now be employed. As such, Zürn mentions creosote, diluted with spirit or oil (1 : 25). Also, among other things, the following are recommended—benzine shaken up with water (1 : 5–10), or a solution of 1 part caustic potash in 30 to 40 parts of water. The above and several

other remedies can be used with good results in combating scabies in most of our domestic animals. But there is more difficulty with sheep than with other animals, for the fleece is a hindrance to the beneficial action of the wash employed. It is not possible to make the sheep quite healthy so long as they remain unshorn. Till then, the efforts made must be directed to preventing the *spread* of the mange. This is managed in the following way. The crust is scraped from the parts attacked, after the loose wool which covers them has been removed. The mangy places are then rubbed with a decoction of tobacco leaves with carbolic acid (1 part carbolic acid to 15 parts spirit and 60 parts water), or with some other of the remedies named above. When the sheep are shorn, first dip them in a solution (2 parts soda, 1 part lime, and 50 parts water) by which the crust on the affected places is softened; twenty-four hours later dip in a solution which will kill the mites. A decoction of tobacco (1 part tobacco to 12 parts water) may be used for this purpose, using for each sheep about $1\frac{3}{4}$ pints of the fluid, to which has been added $6\frac{1}{2}$ drams carbolic acid and $6\frac{1}{2}$ drams alcohol. The first washing must be followed by a second, for the fluid destroys only the mites and not their eggs. As the young mites are hatched out in three to seven days, the dipping must be repeated seven days afterwards.

Family: **Ixodidæ** (*Ticks*).

Ticks are generally rather larger than the mites of the preceding family. The skin is tough as leather. The front part of the body is covered by a hard shield above; the skin of the hinder part, though tough, is very extensible. The front end bears a sucking apparatus formed by the pointed jaws, and by its means the tick pierces the skin of man or animals

and holds on fast. Ticks are chiefly found in sandy soil, among bushes and shrubs, or among herbs. As long as they remain on the ground they are tolerably small ($\frac{1}{10}$ inch) and very active. They creep up haulms and branches, and rest in a suitable spot till a mammal or bird passes, when they attach themselves to its hair or feathers by their legs, and bore into its skin with their sharp mouth parts. Having thus fixed themselves, they suck the blood of their temporary host. The walls of their stomach and intestine are extremely elastic, so that the tick, which at first is only about one-tenth of an inch long and one-sixteenth of an inch broad, becomes as big as a pea, or even a garden bean. When the tick has sucked itself as full as possible, it withdraws its mouth parts from the skin of its host for the time being, and lets itself fall to the ground, where it lies for many weeks without feeding. The small and feeble legs of the tick are not able to move the heavy, blood-filled body, and movements do not take place for some time, till the greater part of the imbibed blood has been digested and the tick has shrunk once more to its normal size. What has been said about the habits refers only to the female; the much smaller male never seems to pierce mammals, and its food is not known. In pairing, it is found attached to the under side of the female, remaining there several days, even when the female is fixed to the host. Egg-laying does not take place till the host is quitted. As ticks draw blood from their host their presence, in spite of the fact that they remain but a short time, is not a matter of indifference, especially if large numbers affix themselves to one animal. Sheep and cattle become thin if daily attacked in the meadows by many ticks. The piercing of the skin causes a stinging sensation, followed later on by itching of the parts to which the

Fig. 127.—The Dog Tick (*Ixodes ricinus*).

ticks are attached. The ticks which are fixed must never be seized and pulled out, for the mouth parts are so deeply imbedded in the skin that it is impossible to remove them by force, and the attempt would only result in tearing the body from the mouth parts. A better plan is to put a drop of oil or tobacco-water, or, still better, benzine, on the tick, when it will loosen itself. We distinguish between the **Dog Tick** (*Ixodes ricinus*), the **Sheep Tick** (*I. reduvius*), and the **Ox Tick** (*I. reticulatus*), which, however, are not found exclusively on the animals after which they are named. The first, although found most commonly on the dog, attacks men who force their way through underwood (hunters), and in the same way fixes on sheep and oxen. The last two species are chiefly, but not exclusively, found on sheep and goats.

Family: **Gamasidæ** (*Beetle Mites*).

Beetle mites are temporary parasites on insects, reptiles, and birds. They have no eyes, but possess shear-like jaws, and tolerably long hairy legs. The **Beetle Louse** (*Gamasus coleoptratorum*) lives on dung beetles, sexton beetles, etc.

The **Fowl Mite** (*Dermanyssus gallinæ*) is the size of a sand grain, and blood-red or red-brown in colour. During the night it is found in large numbers on the fowls, but during the day hides on the perches, in the nests, and particularly in the chinks and crannies in the walls of the poultry-house, also in dung. It draws much blood from the fowls, and disturbs their sleep by producing a constant itching, the result being that they get very thin. *Remedy:* Whitewash the fowl-houses twice a year (autumn and spring) with hot lime to which 5 per cent. of carbolic acid has been added. The wooden parts should be scalded with boiling water before whitewashing.

Family : **Trombidiidæ** (*Running Mites*).

Body four-cornered or longish oval; legs tolerably long, hairy; jaws claw or needle-shaped; surface of the skin velvety; colour reddish or yellowish. They run about with great rapidity on the ground, tree trunks, leaves, etc. Most species feed on the juices which they suck from insects, or from other arachnids.

The **Plant Mite,** or **Red "Spider"**
(*Tetranychus telarius*),

is ovoid, at most one-fiftieth of an inch long; reddish (also yellowish or brownish), with a dark spot on each shoulder. Plant mites are often found in considerable numbers during the summer, especially on the under sides of the leaves of low-growing plants; on garden beans, turnips, and hops; on several ornamental plants, grasses, and various weeds; on roses, limes, horse-chestnut trees, elms, willows, and fruit trees. In some exceptionally dry summers the mite increases to such an extent as to become a great pest. On the upper sides of the infested leaves there is to be seen, besides the adult and immature mites, a whitish, mealy substance, consisting of the cast skins and whitish eggs. Many of the mites run about here and there, but most of them remain fixed, and suck the sap. All are covered by a delicate web, which is formed by the animal. The attacked leaves become limp, shrivel up, die, and fall off. In dicotyledonous plants the withering generally commences in the axils of the veins. The infested plants often die off gradually, but death may also take place with great rapidity. Annuals are often killed by the attacks of the mite. The mites pass the winter in the ground, under fallen leaves, under the bark of trees, etc.

CLASS IV.: **CRUSTACEA** (CRUSTACEANS).

The Crustacea breathe by gills, and are therefore suited to an aquatic life. A few species, however, live in damp earth, or in places where the air is damp (wood lice). Crustacea have two pairs of antennæ, and a large number of appendages arranged in a characteristic way, but differing very much in shape in the different groups; skin usually hard and thick. Lobsters, crayfish, crabs, wood-lice, and the small sand-hoppers, water-fleas, etc., belong to the Crustacea. No Crustacean is harmful agriculturally.

Third Sub-Kingdom: **VERMES** (Worms).

Worms[1] are bilaterally symmetrical animals, in which the body is enclosed in a "dermo-muscular tube." Under the delicate epidermis there is found a layer, which does not, as in the higher animals, consist exclusively of dermis, but is partly composed of muscle-fibres, which form a distinct coat internally. Worms are able to move by contracting the various components of the dermo-muscular tube thus formed. In some worms limbs assist in the movements, but in others this is not so; in any case, however, the limbs play a relatively subordinate part. These limbs, which are only present in the bristle-worms, are small, always unjointed, foot-stumps, which bear bristles. Leeches and some other worms possess suckers by which they can attach themselves, and move by alternately contracting and extending their bodies.

There are segmented and unsegmented worms (thread-worms, liver-flukes); the degree of segmentation is also very various. In many tapeworms each

[1] In ordinary language one understands by "worms" elongated, cylindrical animals; and several insect-larvæ (*e.g.* "wireworms," p. 103) have the name applied to them. But to zoologists all "worm-shaped animals are not worms, nor have all worms an elongated cylindrical shape (liver-fluke).

joint may be regarded as an individual animal. The joints of other segmented worms (earthworms) do not become detached, like those of tapeworms, for the purpose of reproduction. The nervous system is absent in the lowest worms; in the higher worms ganglia always constitute its central parts, and in annelids these are arranged in pairs on the ventral side of the body, and united by nerve fibres into a ventral cord, which is connected in front with a nerve-ring surrounding the gut and thickened above into cerebral ganglia. In many worms (*e.g.* tapeworms and flukes) the nervous system is of much simpler structure. The sub-kingdom of worms contains a very large number of forms. It is only necessary to mention here representatives of three classes: Segmented worms (*Annelida*), round worms (*Nematelminthes*), and flat worms (*Platyelminthes*).

CLASS: **ANNELIDA** (SEGMENTED WORMS).

Segmented worms with rounded (earthworm) or flattened (leech) bodies, and possessing both mouth and anus. They fall into two sub-classes: I. Leeches (*Discophora*), II. Bristle-worms (*Chætopoda*). The first possess suckers as organs assisting locomotion, the latter foot-stumps, which bear longer or shorter bristles; but these foot-stumps may be absent, and the bundles of bristles are then simply imbedded in pits. The latter is the case in the only members of the class which interest us here, *i.e.* the *earthworms*.

The **Earthworms** (*Lumbricus*).

There are several species in the genus, but all agree in their habits. The body of the earthworm is slender and cylindrical, tapering in front and somewhat flattened behind. On the ventral side of the second segment is found the opening of the mouth. There

are no eyes, though these animals are sensitive to the action of light. The earthworm is hermaphrodite (p. 16); when two individuals pair they mutually fertilize each other. On a warm summer evening two adjacent worms creep half out or nearly out of their burrows, and apply the front parts of their bodies together, especially a reddish, swollen part found at about the middle of the anterior half of the body. In this region the glands in the skin are very strongly developed, and secrete a substance which surrounds the eggs as a capsule as they are being laid. Earthworms are chiefly found in damp humus, or, at any rate, not in very poor sandy soil or clay. From time to time they carry their burrows up to the surface in order to get rid of the undigested remains ("worm castings") of the humus and vegetable matters which have been taken into the body. The burrows run down obliquely into the soil, or more rarely vertically, to the depth of eight feet or more; they end in an enlargement, where the worm remains coiled up during the winter, after having closed the mouth of the burrow with a plug of leaves, twigs, paper, straw, etc. Although the earthworm chiefly subsists on the organic matters found in earth rich in humus, it also devours the leaves of cabbage, onion, and other plants, and especially seedlings (particularly those of beet). It draws these parts of plants about four-fifths of an inch into its burrow, and moistens them there with an acid fluid it secretes, and which acts upon them before they are taken into the body. Earthworms may effect considerable damage by destroying seedlings, particularly in damp fields, though this damage is always local. A not inconsiderable amount of benefit is to be set against this. By means of the burrows which they dig earthworms cause air to penetrate into the soil much better than it could otherwise do, which is known to be of the greatest importance for plant life. Earthworms are extremely

important owing to the large numbers in which they are present in the soil, and for another reason besides the one just given. Darwin shows that in many parts of England a weight of ten tons of earth per acre passes through the bodies of earthworms, and is brought to the surface by them, so that in a few years the entire humus-containing surface layer of earth has passed through their bodies. They therefore prepare the soil in an excellent manner for the growth of plants, by continually exposing it to the air. They cause stones to sink in the soil by throwing out at the top earth which naturally consists only of particles small enough to pass through their intestines. They play the part of gardeners by thoroughly mixing together the particles of soil, and bury under their castings, in a shorter time than one would imagine, objects found on the surface of the soil (bones, oyster-shells, dead animals, leaves). Plant-food is quickly formed again from these buried matters. Earthworms, therefore, play a very important part in the economy of nature; indeed, many regions, now occupied by luxuriant pastures or fertile cornfields, would be a waste, had it not been for them. Where, however, in damp spots they injure seedlings, they may be collected, either during the day after a warm rain, or in the evening, at which times they lie half out of their burrows. If a decoction of walnut leaves is poured into these, they will crawl out. *Enemies:* Mole, shrews, hedgehog, toads and frogs, ground beetles, rove beetles, mole crickets, centipedes, etc.

CLASS: **NEMATELMINTHES** (ROUND WORMS).

Body cylindrical, unsegmented; body wall tough, hooklets or spines may be present on it, but deeply imbedded bristles are always absent. The gut may

be absent (some parasites), but this is exceptional. There are no special organs for circulation and respiration. Sexes distinct in the large majority. I will deal with only one of the orders belonging here.

Order : **Nematoda** (Thread Worms).

Elongated, thread-shaped or spindle-shaped, unsegmented. A gut, terminating in a ventral anus, is present. Outer investment of the skin smooth, often weakly ringed or striated. The muscle layer underlying the true skin is interrupted here and there, where the skin itself stretches further inwards. In this way are distinguished the *lateral lines* or *fields* (Fig. 128, *a*), which run right along the sides of the body, dividing it into a dorsal and a ventral region. There are often present as well two smaller but similar

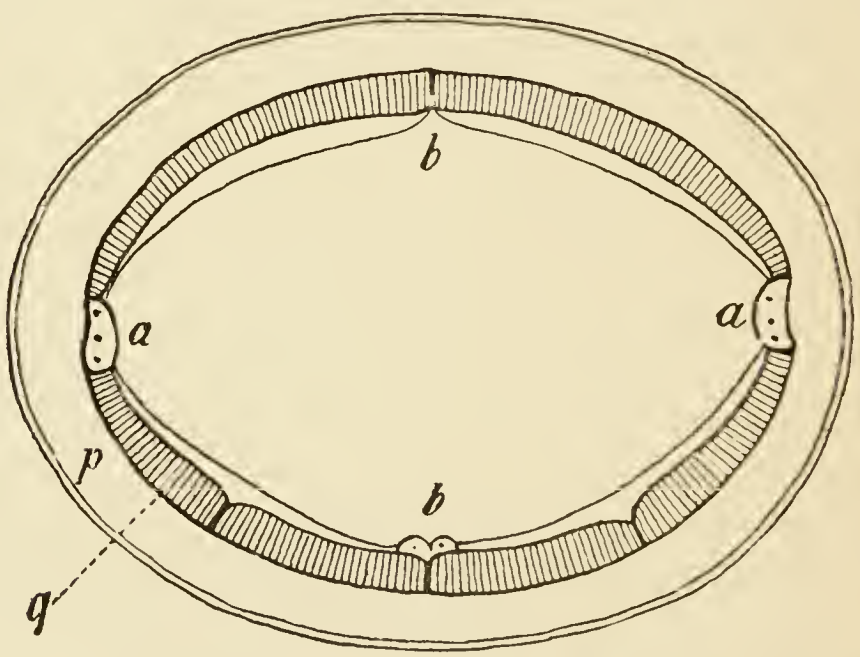

Fig. 128.—Diagrammatic transverse section through the body of a Thread Worm, internal organs being omitted: *p*, cuticle and skin; *q*, muscle layer; *a*, lateral lines; *b*, dorsal and ventral lines.

dorsal and *ventral lines*, respectively situated above and below (Fig. 128, *b*). Mouth usually surrounded by lip-like folds, but more or less distinct jaws may also be present. The anus either lies at the apex of the tapering posterior end of the body (*trichina*), or

further forward, on the ventral surface. Among the Nematodes are included a number of relatively small species, living free in the earth, and sucking plant-parts, while other forms fairly closely related live parasitically in plants, and often cause very serious plant diseases (*e.g.* Beet Eelworm); a larger number of species are parasitic in animals. The free forms and those parasitic in plants lay relatively few, but very large, eggs, although, in several species, increase is furthered by a succession of many generations in the year. The Nematodes parasitic in animals lay very numerous eggs, even several millions. Harmful species are known from the following families: 1. **Palisade Worms** (*Strongylidæ*), 2. **Whip Worms** (*Trichotrachelidæ*), 3. **Slender Thread Worms** (*Filaridæ*), 4. the **Round Worms** (*Ascaridæ*), 5. **Eelworms** (*Anguillulidæ*).

I will successively treat of the harmful forms, but since many species belonging to different families infest the digestive organs of the different domesticated animals, causing similar symptoms of disease which may be dealt with in much the same way, the following general sketch is first given:—

Nematodes in the Gut (more in young animals than old) cause the following *symptoms:* (1) Appetite variable. (2) Nutrition in general affected, even if sufficient food is taken; constipation or diarrhœa; belly much drawn in or else, and usually, swollen out. The animal itself is thin, and has (except horse) a tendency to vomit. (3) An itching all over the body, especially at the nostrils and anus. The animal rubs and bites the sides of its body. (4) Tongue covered with a thick, soft, yellowish coating. A sweet smell from the mouth. (5) The skin is tense, lacking its usual elasticity. (6) The animal suffers from spasmodic colic, and (7) disturbances of the nervous system (whining or crying; unrestrained or suppressed fits). *Remedies:* Horses and cows

infested with thread worms may be given chopped carrots, beets, and turnips, previously mixed with sugar or crushed sugarcandy. Roasted oats are also good. For sheep finely crushed glass, kneaded into pills with bread, will always suffice. Gritty sand in the food may also be of use. Pigs should be given sour milk, acorns, unripe cheese, horseradish. For dogs, sausages containing garlic, as much flesh food as possible, strongly salted food, milk boiled with garlic. In all cases iron may be given. The advice of a veterinary surgeon should be sought in the matter of medicines (tansy, male fern root, tartar emetic, arsenious acid, etc.).

Family : **Strongylidæ** (*Palisade Worms*).

Spindle-shaped; anus on the tip of the hind end of the body; in all thread worms the rectum and male sexual organs open by a common cloacal opening, which, in the palisade worms, is surrounded by an umbrella, or cup-shaped apparatus (*bursa*), kept expanded by means of muscular ribs (Fig. 129).

Here belong—

The **Giant Palisade Worm**, or **Strongyle**, (*Eustrongylus gigas*). Female from a foot to thirty-nine inches long, and as much as two-fifths of an inch thick. Male six to sixteen inches long; reddish. Lives in the cavity (pelvis) of the kidneys in horses, oxen, dogs, and man; causes degeneration of the kidneys, with blood in the urine, nervous diseases, and disturbance of the feelings and intelligence.

The **Armed Palisade Worm**, or **Strongyle** (*Strongylus armatus*), four-fifths of an inch to two inches long, one twenty-fifth to one-twelfth of an inch thick; reddish brown. Taken into the gut of the horse with the drinking water as a young, minute worm, it bores through the walls of this organ into the blood-vessels branching there. Later on it bores into the walls of the larger arteries of the hinder part of the

body, especially into those which carry blood to the wall of the gut (particularly anterior mesenteric artery). At those parts of the arterial walls where it collects in large numbers, swellings (aneurisms) are produced, varying from the size of a pea to that of a hen's egg. A constriction is often developed quite close to this swelling, and a plug of fibrin may also

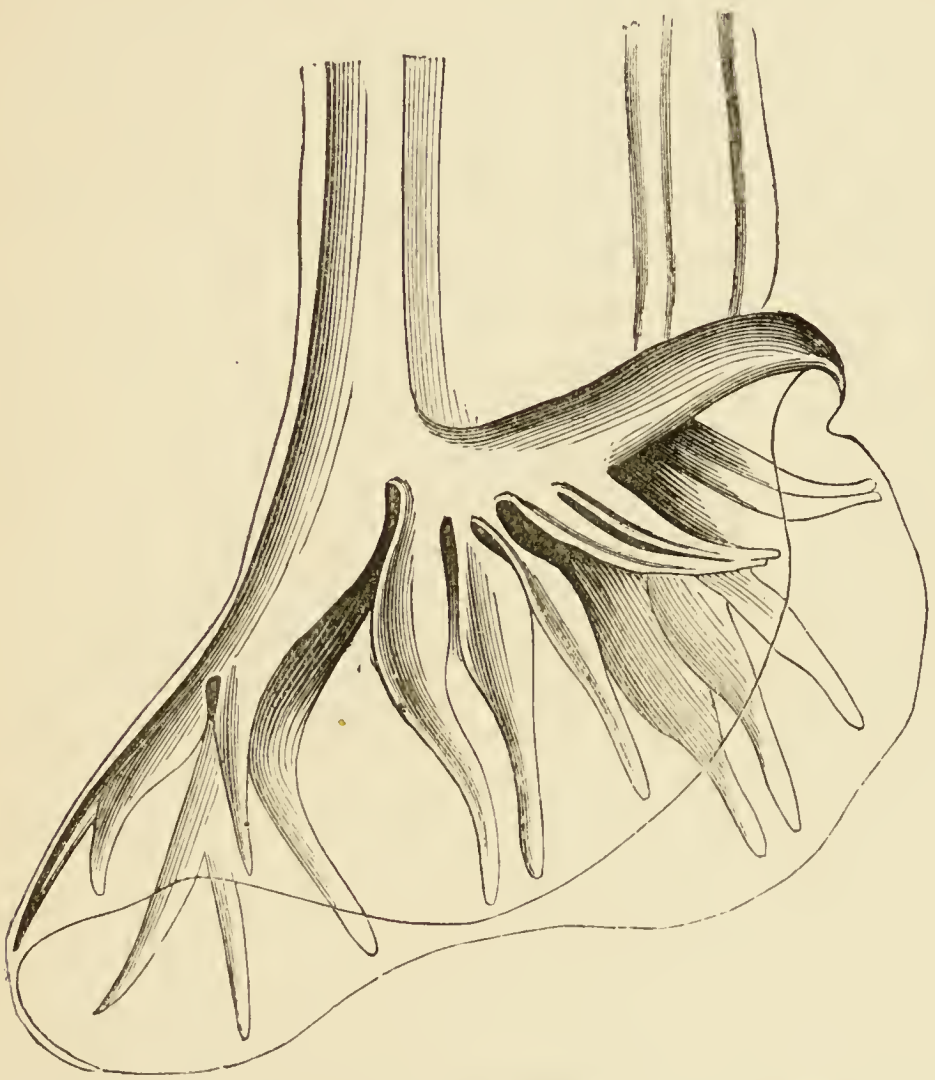

FIG. 129.—Tail of male *Strongylus armatus*, strongly magnified.

be formed within the artery, so that the circulation in the wall of the gut is greatly hindered. As a result of this the glands and muscles in the wall of the digestive tube refuse their office, so that regular digestion and onward movement of the food do not take place. This leads to colic. As soon as the strongyloid larvæ have become adult, they pass from

the walls of the arteries into their cavities, and are carried by the blood-stream to the walls of the gut, which they penetrate in order to reach its cavity, where (cæcum and large intestine) they pair, after which the female lays eggs, which are carried to the exterior in the dung. The quickly hatched young seek water, mud, or damp earth, where they live until, by some means (*e.g.* with the drinking water) they manage to enter the gut of a horse or (more often) ass. *Preventive Measure:* Horses and asses must not be allowed to drink stagnant water.

The **Stomach Palisade Worm**, or **Strongyle of the Sheep** (*Strongylus contortus*). Male one-half to two-thirds of an inch, female three-quarters to four-fifths of an inch long; whitish or reddish, somewhat coiled at both ends. The disease of the stomach, and diarrhœa, which affect lambs, usually in spring, and result from the presence of these worms in large numbers in the true or fourth stomach, lead to emaciation, weakness, and poverty of blood. Development unknown. Nutritious food will cure lambs which are not very badly infested, but hastens the death of those which are.

The **Lung Worm** of Lambs (*Strongylus filaria*). Male an inch, female as much as three and a half inches long, thread-shaped, white or yellowish. It appears that the young worms are taken into the stomach of a lamb (or sheep) with the drinking water; they are found there in May, June, and July. They quickly climb back into the throat, from which they get into the windpipe and its branches. There they penetrate the mucous membrane, where, until they have reached the sexual stage, they are found imbedded in small swellings, which they quit at the end of winter or the beginning of the next spring, if their host lives so long. The female bears living young, which as very minute worms may be met with by the hundred in the mucous lining the windpipe and its branches. A direct transference of the parasite from one sheep

to another does not take place, since the young born in the mucus secreted by the walls of the air-tubes must first live and grow for some time in water or slime before they are able to undergo further development in the body of a sheep or lamb. The fate, however, of the young worms which pass to the exterior in the mucus is not yet sufficiently known. *Symptoms of Disease:* Running of slime from the nose, difficulty of breathing, cough, emaciation, poverty of blood. Death ensues in from two to four months. Recovery only of very strong individuals infested by comparatively few parasites, most of which they cough out. *Preventive Measures:* In regions where the evil is very prevalent the young sheep must not be allowed to go into the meadows. If it is impossible to keep them penned in, a little food and water may be given before sending them to pasture in the morning. In this way the danger of infection will be somewhat lessened, since it is then less likely that the animals will eagerly betake themselves to pools and ditches in order to quench their thirst. Since during the months May to July the young worms (most probably taken in with the water drunk) are found in the stomach, it is good during this time to give vermifuges to the lambs and sheep. For medicines a veterinary surgeon should be consulted.

The **Small-tailed Palisade Worm**, or **Strongyle** (*Strongylus micrurus*). Thread-shaped; male one and two-fifths, female two and two-fifths to two and four-fifths of an inch long; lives in oxen (especially calves) in swellings of the arteries, also in the wind-pipe and its branches. Severe bronchitis.

Family: **Trichotrachelidæ** (*Whip Worms*).

Small, slender, elongated worms, with the anus or, in the male, cloacal aperture at the hinder end of the body; the latter, however, is not—as in palisade

worms—surrounded by an umbrella or cup-shaped expansion. Here belongs:

The Trichina (*Trichina spiralis*).

In the sexual condition this lives as a minute worm (male one-seventeenth, female one-eighth to one-sixth of an inch long), the so-called "intestinal trichina," in the gut of human beings and carnivorous mammals. In this situation it brings forth living young (some fifteen hundred in number), and the multiplication is enhanced by the fact that of the very numerous trichinæ found in the gut there are, on the average, about twelve females to every male. The young trichinæ bore into the walls of the gut, and are carried by the blood-stream into the muscles. At first each little worm extends itself longitudinally in a muscle fibre, but, as it gets larger, curves and becomes spirally twisted, so that the sheath (sarcolemma) of the fibre is bulged more and more outwards. The growth of the young trichina is very rapid—an individual only $\frac{1}{250}$ of an inch long before leaving the gut may attain the length of one twenty-fifth of an inch in fourteen days. It then grows no more, and the sheath of the muscle-fibre gradually thickens to form a capsule or cyst. Later on, in about a year, lime is deposited in the capsule. The "muscle trichinæ" retain their vitality for several years. If now the host of the muscle trichina is devoured by any other mammal, the capsule is digested in the stomach of the latter, and the once more liberated worm becomes a sexually mature "intestinal trichina" in a few days. The pig is the ordinary host of trichinæ, which (without the intervention of any other host) can be permanently parasitic in this domestic animal, since pigs often devour swine's flesh. They often enough devour even their own young, and, especially in large slaughter-houses, swine are often fed with the offal of their

companions. The trichinæ also spread through the body of any living being (men, rats) which eats trichinous pork. The trichinæ thus introduced cause, in the human subject, a dangerous or even fatal disease known as *trichinosis*. The size of this book does not permit me to describe the symptoms of this complaint in man. Pigs suffer much less from the parasite; they may even contain an enormous number of trichinæ in their muscles without being noticeably ill. Symptoms of disease, however, often appear more or less clearly. A short time after eating the trichinous meat the appetite of the pigs is bad; they appear

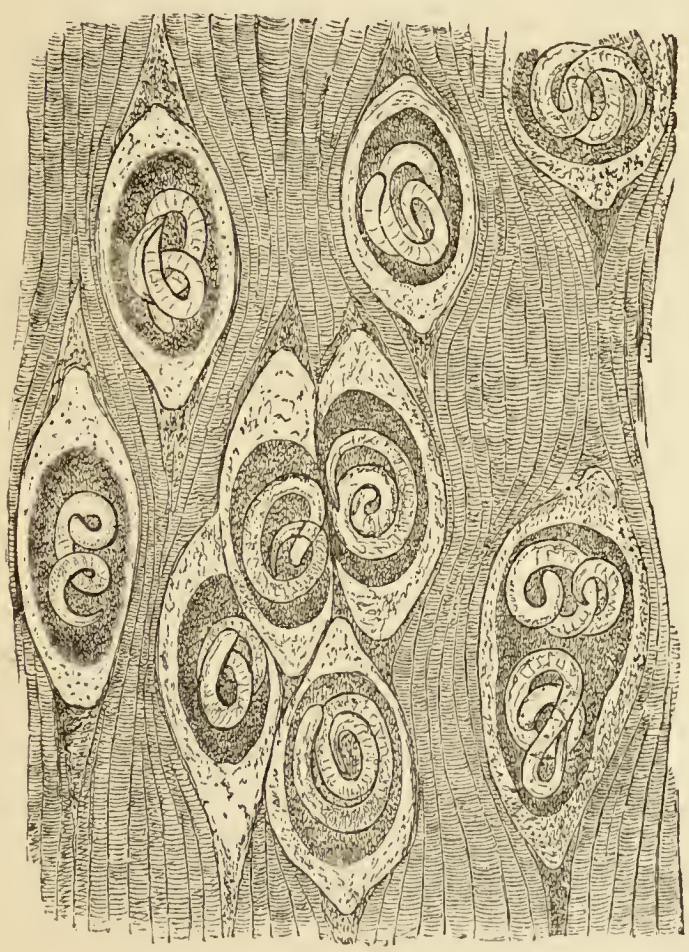

FIG. 130.—Encapsuled Muscle Trichinæ in flesh, strongly magnified.

FIG. 131.—Male Intestinal Trichina, strongly magnified.

in bad spirits; the tail straightens out, and they often remain standing with bent limbs and arched backs. There may be, in addition, pains in the abdomen, diarrhœa, and fever. Later on, when the trichinæ have settled down in the muscles, the pigs suffer from stiffness in the legs and tenderness in the loins; they often cry out in pain. After this, however, health and appetite may return, and they can be fattened. Trichinous swine therefore appear quite sound, and are slaughtered in due course. The trichinæ in the pig are found most abundantly in the diaphragm, the masticatory, eye-, and other muscles of the head, also in those of the neck, larynx, abdomen, and loins. The fore part is more infested by trichinæ than the hinder part, but in very bad cases they are found everywhere, even in the hams. *Remedies:* (1) The swine must be prevented, as far as possible, from taking up trichinæ, and therefore must never be given the offal from other slaughtered swine. The flesh of trichinous swine should be burnt, and not buried, lest dogs or other animals should eat it and spread trichinosis. (2) Care must be taken that no trichinous pork is eaten by human beings (microscopic examination; meat inspection). Pork (or sausages) must never be used raw or half cooked. Trichinæ are killed by a temperature of 140° to 150° F. The *inside* of the piece of meat must be exposed to this temperature.

Family: **Filaridæ** (*Slender Thread Worms*).

Elongated and thread-shaped. Round mouth. Do not infest the gut or other cavities, but the tissues of the body, chiefly connective tissue. None of the species require notice here.

Family: **Ascaridæ** (*Round Worms*).

Relatively shorter than the worms of the preceding family. Mouth triangular, surrounded by three teat-

shaped lips. In the male the hinder end of the body is usually bent in a hook-like manner. The anus is not placed quite at the hind end of the body. All the species inhabit the alimentary canal (Cf. p. 211).

Horse Worm (*Ascaris megalocephala*). Male six to eight, female twelve to seventeen inches long; sometimes occurs in great balls, causing stoppage.

Round Worm of Cat (*Ascaris mystax*). Male two to two and two-fifths, female four and four-fifths to five and one-fifth inches long; in the intestines of the cat. *Ascaris marginata* infests the dog.

Pinworm (*Oxyuris curvula*). Male one-fourth to one-third, female one and four-fifths of an inch long. In the rectum of the horse, causing persistent itching.

Family: **Anguillulidæ** (*Eelworms*).

Extremely small, thin-skinned; lay only a few relatively large eggs, which develop very quickly. With few exceptions either earth eelworms (*i.e.* live in decomposing organic matter or humus soil) or as plant parasites leading to characteristic diseases of wild and cultivated forms. All these parasitic forms have a "mouth spine." This structure, found in the mouth cavity, is very sharp and pointed in front, and can be worked forwards and backwards so as to penetrate the cell walls of plants. A mouth spine is not only found in the species which infest plant tissues (several species of *Tylenchus* and *Aphelenchus*, as well as all the known species of *Heterodera*), but also in those forms living free in the earth which bore into the exterior of plant roots (the remaining species of *Tylenchus* and *Aphelenchus*, *Dorylaimus*, etc.). In all cases an eelworm, devoid of a spine, is not a plant parasite. I will only deal with those parasites by which well-known destructive diseases of cultivated plants are caused. These belong to the genera *Tylenchus* and *Heterodera*. The first remain eel-shaped

throughout life, but the adult females of the latter swell out considerably and become lemon- or pear-shaped.

The **Stem Eelworm** (*Tylenchus devastatrix*).

Length one-thirtieth to one-fifteenth of an inch long, usually of intermediate size; the two sexes of approximately equal length. Live and reproduce in various cultivated plants (*e.g.*, rye, oats, stored onions, hyacinths, buckwheat, potatoes, clover, fuller's teasel) and wild plants (*e.g.*, *Poa annua, Anthoxanthum odoratum, Dipsacus silvestris, Polygonum persicaria*), but not to the same extent in all. It must also be added that eelworms of which the progenitors have developed for a considerable number of generations in the same plant, are not easily transferred to another kind of plant, or at any rate do not multiply vigorously there. Eelworms, of which the ancestors have lived for many years exclusively in rye, or alternately in rye and buckwheat, do not readily pass over to seedling onions, and first only reproduce in them to a small extent. The eelworms live only in stems, branches, and leaves, never in roots. In the places where they have penetrated the plant tissues an abnormal growth in thickness of the parts involved takes place, while the growth in length is either much diminished or even entirely stopped. Also the chlorophyll disappears sooner or later from the attacked spots, and rapid death generally ensues. Since only those parts of an organ which are inhabited by a large number of eelworms swell much, it is obvious that cracks are often developed in the stems and leaves concerned. It is further easily seen that the species and constitution of the infested plants will have an important influence on the progress of the disease caused by the eelworms. But since several generations of this parasite succeed one another

during the same year, the resulting malformation is usually very considerable. "Clover sickness" is probably due to this eelworm.

I will treat in somewhat greater detail the **Eelworm Disease** of rye, which is largely prevalent in Westphalia and the Rhine provinces, and had already made its appearance, in the latter at least, at the beginning of the century.

The eelworms producing the disease migrate into the soil on the ripening or death of the grain, and later on go back to the new young rye plants or to other plants in which they can live, as the case may be. It is therefore clear that (1) where this disease exists the soil is infected for a time, and (2), the eelworm disease of rye principally appears in regions where the culture of rye is carried on to excess. Germination of the seed-corn goes on quite normally in infected fields, and it is only exceptionally that anything particular is noticed in the young plants of winter rye during autumn and winter. The disease appears at the beginning of spring. Some plants soon become yellow and die: others appear to grow very luxuriantly; they possess a beautiful bluish-green colour and seem very healthy; later on they develop enormously in breadth, and each separate plant covers a relatively large area. The base of the stem swells abnormally, so that the plant looks as if it bore below an onion projecting above the ground. This is caused by the lower joints of the haulm remaining very short and thickening considerably, causing the leaf-sheaths which surround the base of the stem to become thicker and broader than usual. The feeble development of roots is also characteristic. The leaves generally remain short, but get very thick; they often become wavy, and may even appear frilled. All the leaves, however, are not crumpled in this way; a few remain quite normal, while others are small and grass-like, but thick (Fig. 132). Later on, the tip of

Fig. 132.—Rye plant in the later stage of the Eelworm disease.

the haulm and the ear often do not come out of the leaf-sheaths; in other plants the ear may appear, but remains small and deformed as well as the rest of the haulm, while the grains which develop are small. A number of shoots, however, may develop normally and bear fruit. Badly infested plants quickly die, some at the very beginning of spring, others later.

Where the disease is very bad it may easily be recognized by its characteristic distribution. A number of bare places are noticed in spring on the infected fields; round about these places still living but badly diseased plants may be noticed, and the symptoms of attack are less obvious the further one goes from the bald spots.

On the death of the rye-plants the eelworms mostly travel back to the soil, but sundry eggs and larvæ stop in the dried-up remains. Rye straw may further infect a diseased field by getting into farmyard manure and being brought back again with it; for the eelworms (at any rate as eggs and larvæ) are killed neither by drying nor by the action of dung and other decaying substances. Strongly infected spots (bare patches) on an infested field are usually the places where dung containing diseased rye-straw has lain for some time. From such centres the spreading of the eelworms takes place: (1) *actively* by the migration of the worms, (2) *passively* by rain, the feet of labourers, the hoofs of horses, field implements, etc.; also (on loose soils) by the wind, which not only blows about particles of earth, but also the dried-up larvæ which are always found on the surface of the ground. As the eelworms multiply very rapidly whenever they are in the plants, and as the means of distribution are very numerous, the disease spreads with great rapidity.

Remedies.—Proper rotation; limitation of the culture of rye, growing in place of it carrots, turnips, or lupines. Now and then (but not too frequently),

potatoes, buckwheat, clover, and oats may be cultivated in the fields affected, at any rate before sowing rye again. Abundant manuring, especially with sulphates of potash, ammonia, and iron. Deep cultivation of the soil, since the eelworms find no food in the deeper, damper layers of the soil, nor can they pass into the dried condition, and so must die.

Oats suffer from eelworms just in the same way as rye.

Clover Sickness is marked by short stunted shoots, and whitish rounded buds, often remaining closed; also by the whitish colour and abnormal thickening of the shoots and buds.

Eelworm Disease of Potatoes.—Crumpling and small growth of the parts above ground. In many cases there may even be no potatoes at all, or only small ones, poor in starch, though sometimes they may be tolerably large. On the surface of the tubers there are discoloured rotten spots, not penetrating deeply, and usually (but not always) at the attached end. These dark patches contain the eelworms.

Eelworm Disease of Buckwheat.—Joints of the stem for the most part much thickened, but abnormally short. In many cases a large amount of branching in the lower part of the stem, usually at a place where it bears a nodular swelling. Branches generally short. There may be twists and bends in the stem and branches. Often, but not always, the formation of flowers and fruit is stopped. The thickened parts of the stem are brittle; they contain the eelworms in their interior.

The **Wheat Eelworm**
(*Tylenchus scandens* = *T. tritici*).

Length of the male about one-twelfth of an inch, of the female one-tenth to one-fifth of an inch (according to the size of the galls in which the eelworms develop). The wheat eelworm is the cause of "ear cockles," also

known as "peppercorns" and "purples." In several parts of the ear short thick dark-brown galls (Fig. 133), resembling the seeds of corn-cockle, are found instead of wheat grains. Inside the thick brown shell there is a yellowish-white mass, containing hundreds or even thousands of eelworm larvæ (one thirty-first to one twenty-seventh of an inch long). These are quite dry and rigid, but gradually revive on moistening, even if the black galls have remained twenty years in the dried-up condition. When the wheat is ripe the dark-walled galls are gathered in with the crop, and in many cases are sown again with the sound grains. The brown shell then decays, and the eelworm larvæ leave the gall, travelling to a neighbouring wheat seedling, where they live between leaf sheath and haulm, also penetrating into the terminal bud. The haulm of a wheat plant infested by many eelworms remains relatively short, the leaves are often sharply bent and have wavy margins. Wheat plants thus infested closely resemble rye plants diseased in a similar way, but are much less deformed. This is because the wheat eelworms do not reproduce till they reach the ear, and there is consequently only one generation per year, while several generations of eelworms succeed one another in the same rye plant. The eelworms quickly travel from all parts of the plants into the ears, and get into the rudiments of the flowers, causing them to swell up like bladders, and their walls to become first dark green, and then dark brown. Sixteen to twenty eelworms are present in the lowest flowers of the ear, ten to twelve in those higher up (and therefore smaller), and four to six in the topmost (smallest) ones. Soon after entering the flowers the eelworms

FIG. 133.—Ear Cockles of Wheat; the third shows the eelworm larvæ on its cut surface.

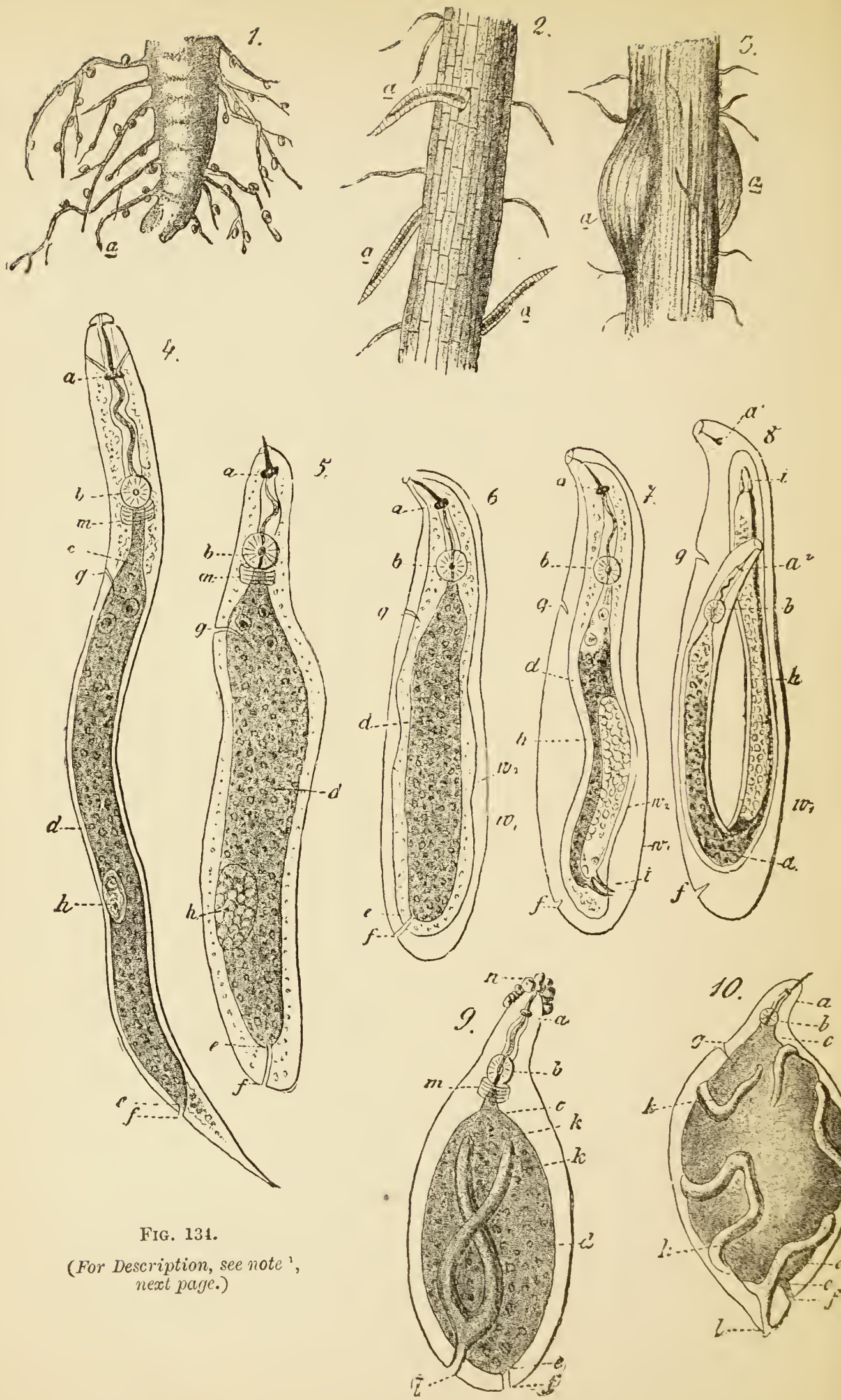

FIG. 134.

(*For Description, see note* [1], *next page.*)

become sexually mature, and lay eggs (600 to 1600), from which are developed the larvæ that inhabit later on the cockle-seed like galls. The disease is known in England, Germany, France, and Italy, and is especially harmful in Saxony, where it sometimes attacks a quarter of the wheat crop. *Remedies:* Either there should be no ear-cockles in the seed corn, or else the eelworms should be destroyed in them. The infested grain may either be put through a sieve, or else soaked for twenty-four hours in weak sulphuric acid (one pint strong acid to thirty-three gallons of water), when many of the galls float and can be skimmed off, while the eelworms are killed in those which sink.

The **Beet Eelworm** (*Heterodera Schachtii*)[1]

is the cause of the "beet sickness" of the soil. The course of the disease is as follows. At the end of July light-coloured patches are found here and there among the normally developed beet. The leaves are weak and limp, and the outer ones especially get yellow, spotted, and die off. Later on the inner leaves die as well, after which the top of the beet becomes black and the whole root gradually decays. In less severe cases the beet may recover towards autumn and develop new heart leaves, but the roots remain small and the crop is poor, often being only one-third of its normal amount. Kühn has proved by infection experiments that the sole cause of beet

[1] FIG. 134.—The Beet Eelworm (*Heterodera Schachtii*): 1, A beet root with adult females attached (natural size); 2, a lateral rootlet of beet which Eelworm larvæ (*a*) are penetrating (enlarged); 3, a lateral rootlet of beet with swelling (*a*) of the outer skin caused by the excessive development of larvæ which have previously entered it, and which have now become nearly mature females (enlarged); 4, a just-hatched larva; 5, a larva which has penetrated a root and swollen up into a club-shaped form; 6–8, development of the male; 9, a nearly adult and, 10, an adult female. The following letters have reference to Figs. 4–10: *a*, mouth spine,—*b*, sucking stomach (pharynx),—*c*, *d*, intestine,—*e f*, rectum,—*f*, anus,—*g*, excretory organ; *h* (in Figs. 4–7), rudiments of the sexual organs in the undeveloped larvæ; *h* (in Fig. 8), testis; *i* (in Figs. 7 and 8), copulatory spicules of the male; *k* (Figs. 9 and 10), ovary; *l* (Figs. 9 and 10), female sexual opening; *m*, nerve ring; w_1 (Figs. 6–8), larval skin; w_2 (Figs. 6–8), new skin which the developing male forms within the larval skin. Figs. 4 and 5 are magnified more than Figs. 6–10.

sickness is a nematode, of which the life history is as follows. The female is found fixed to the branches of the root; it is citron-shaped, about one twenty-fifth of an inch long (Fig. 134, 1 and 10), and contains on an average three hundred and fifty eggs. Some few of these, together with a jelly-like substance making up an "egg-sac," may pass out to the exterior, but the large majority develop in the body of the female, which ultimately becomes a mere sac enclosing the eel-like larvæ. The female is killed by the process. The liberated larva (Fig. 134, 4) seeks out a root (about one twenty-fifth of inch thick), and bores into it. Here it lives as a parasite, causing the disease of the attacked beet plant. The larva quickly sheds its old skin, assumes a thicker form (Fig. 134, 5), ceases to move, and gradually causes the outer skin of the root to bulge out externally (Fig. 134, 3, *a*). The distinction between the sexes now rapidly makes its appearance. A thick motionless larva, destined to become a male, temporarily ceases to feed, shrinks within its old skin, develops a thin new one, and ultimately becomes a long eel-like worm (Fig. 134, 6, 7, 8), which grows into an adult male (8). In the stage represented in Fig. 134, 8, the animal still lies under the outer skin of the root, which never bursts during its development, but the mature male bores out of its larval skin and out of the root, passing into the soil, where it finds and fertilizes the female, which in the meantime has developed but remains attached to the root. The female develops in a simpler way, by the gradual distension and growth of a larva (not by a process of re-formation) and gradual development of the female sexual organs. As the larva passes from the stage of Fig. 134, 5, into that of Fig. 134, 9, and later on into the adult condition, 10, the outer skin of the rootlet is ruptured, and the female comes out from its tissues, remaining, however, attached to its

outside (Fig. 134, 1). The entire development from egg to sexual adult takes four or five weeks, and there may be six or seven successive generations, the reproduction is consequently very rapid.

It also obviously follows that "beet sickness" of the soil is especially prevalent in fields where there has been an excessive amount of beet culture. The disease, however, may suddenly appear in fields which have been hitherto "safe" for beet, and in many such cases it has been proved to result from manuring with artificial compost rich in refuse from affected fields. The disease frequently appears, too, in fields where beet have never been cultivated, but where cabbage has been grown for a long time. It has been shown, especially by Kühn's investigations, that the beet eelworm can live in many plants both cultivated and wild, *e.g.* of the former, cabbage, rape, mustard, garden cress, chickling peas, mangold, oats; of the latter, charlock, spurrey, couch grass. These researches are of the greatest importance both for understanding the way in which beet sickness spreads and in combating it.

Preventive Measures: Manufactured compost must not be used as a manure on beet-fields. The refuse from infested beets, if used on other fields, must be mixed with one-sixth its bulk of quicklime. The boots of labourers employed in beet-sick fields, the hoofs of horses working in them, and also the implements used, must be carefully cleansed lest infected earth should be carried to other fields. *Remedies:* Kühn has recommended the use of plants which attract the eelworms ("lure-plants"). He sows on beet-sick land rapidly germinating plants, of kinds which the worms readily attack, and weeds them out again when they have become infested by the parasites, but before these have had time to mature and re-enter the soil. The eelworms are thus allured into the plants grown, and destroyed with them. Such

lure-plants must be sown as thickly as practicable, so that the soil may be penetrated by as many slender rootlets as possible. After these plants have been dug up, a second lot should be grown, since all the eelworms will not have attacked the first lot; and it is even advisable to grow a third batch. Kühn used as lure-plants the various kinds of cabbage, also summer rape (*Brassica rapa*), since this plant has a great attractive power for the beet eelworms, and can hold a large number of them in its numerous, much branched rootlets. I cannot go into all Kühn's researches here, and will only mention the following. In the course of the year 1880 part of a beet-sick field had three successive crops of lure-plants grown upon it, each being dug up from thirty to forty days after sowing. The field was ploughed in autumn, suitably manured the next spring, and sown with beet in the middle of April. The other part of the piece of land was treated in exactly the same way, except that no lure-plants were grown upon it. A difference was very soon seen between the two plots, and there was a very great difference at the time the crop was ready to be gathered in. The plants on all parts of the first plot were in a flourishing condition, but those on the second plot were in many places either killed outright or else small and misshapen. The crop succeeding the lure-plants was three times as great as it had been before, and almost equal to that of a healthy field. Later on, Kühn made an important discovery; he found that larvæ which have reached the thickened motionless stage, depicted in Fig. 134, 5, require a considerable amount of food to keep them alive, and enable them to develop further. If the plants are disturbed in such a way as to kill the rootlets containing the larvæ in this stage, these are unable to develop any further. Kühn caused a kind of horse machine to be made, adapted for rapidly destroying the lure-plants in the fields. For further details, his original memoirs may be consulted.

The **Root-knot Eelworm** (*Heterodera radicicola*).

This second species of the genus *Heterodera* develops much like the beet eelworm, living like it on the roots of plants, but more deeply within them, so that the body of the female (which swells till it becomes pear- or flask-shaped) does not cause the outer part of the infested root to project, and does not reach the exterior. Where the eelworms collect, galls are formed which decay later on, when the eel-shaped larvæ escape into the soil, very soon, however, to enter the roots again at their slender tips. The galls are thickenings in the course of the root, and are never lateral appendages, like, for instance, the well-known "tubercles" in the roots of leguminous plants (*e.g.* clover, pea). The root eelworm lives in the roots of more than fifty plant species in the most various parts of the world, and infests both weeds and cultivated plants. It is especially damaging to clover and lucerne, in which not only the galls die, but also all parts of the root below them. In this country the roots of cucumber and tomato are sometimes attacked (E. A. Ormerod).

CLASS: **PLATYHELMIA** (FLAT WORMS).

Flat worms have a flat, generally leaf-like body, and usually no body-cavity, the space between the internal organs and the muscular body wall being filled up with connective tissue.

I will only deal here with the orders of Tapeworms (*Cestoda*) and Flukes (*Trematoda*).

ORDER: **Cestoda** (TAPEWORMS).

The external characters of an ordinary tapeworm may be gathered from Figs. 135 and 136. A very small "head" continued behind into a small "neck"

can be distinguished, and a very large number of joints, of which the first are very small and short, while those which follow get larger and larger the further they are from the head. The tapeworm at first consists only of a head which holds on to the lining of the intestine by means of suckers or similar structures. The hinder part of the head next elongates to form the so-called "neck," and a cross-wall is quickly developed a little way in front of the hind end of this neck. By this division is formed the first joint, which, though forthwith tolerably independent, remains attached to the neck of the tapeworm head, until a new joint is separated off from the hinder part of the neck, immediately in front of the first joint. Every new joint is similarly formed by the constriction of the hinder part of the neck. Each joint possesses a complete set of hermaphrodite reproductive organs; it becomes sexually mature without reference to other joints, breaks off, and creeps about,

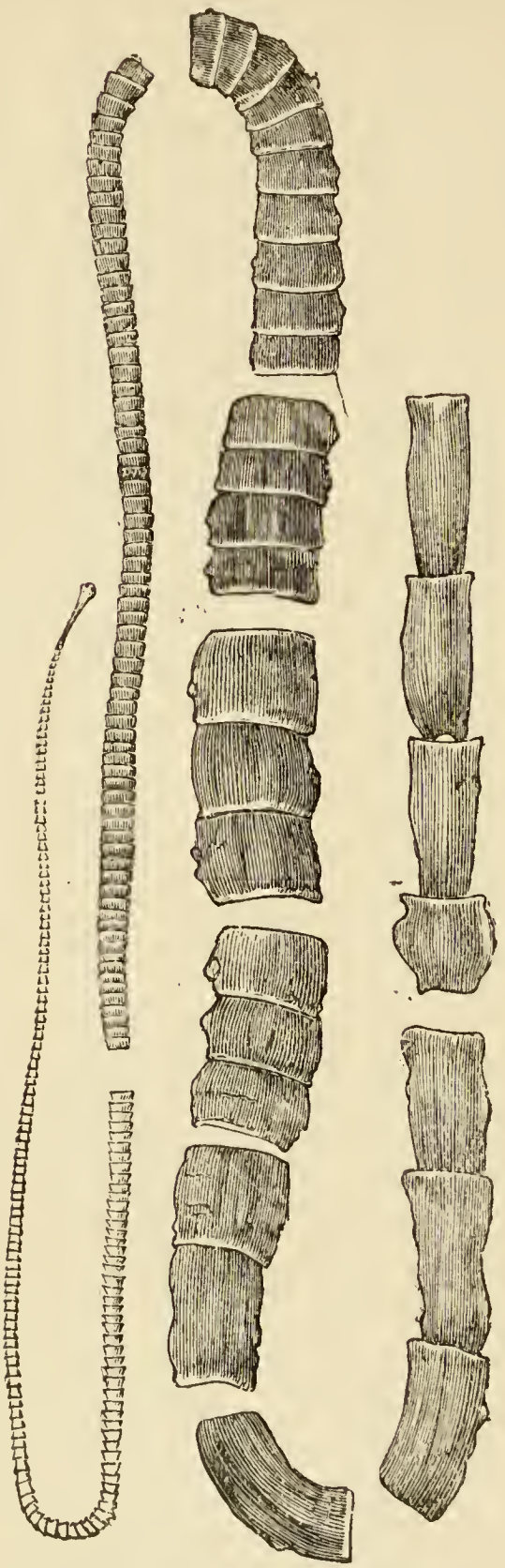

FIG. 135.—*Tænia saginata:* head, and a number of joints, represented natural size.

even for considerable distances, and finally ruptures, so that the numerous eggs are liberated. Each joint may therefore be regarded as an individual, though the tapeworm, considered as a whole, also possesses a certain individuality. The tapeworm is a species of animal which exists in two forms. One of these is the sexually reproducing joint, which leaves the original host, and from the eggs of which are developed larvæ, which become, in another host, *bladder-worms*, or *measles*. These develop a *head*, which is the asexual second form of the tapeworm. This, therefore, is a case of metagenesis (p. 16). It appears, from what has been said, that the head can in no sense be compared to the head of an ordinary animal; it has neither mouth nor jaws, for tapeworms do not possess a gut. The head and joints take up osmotically through their walls the nutritive matter found in the intestine of their host. There are suckers and, in several species, a circlet of hooks on the head (Fig. 136, *a*), by which the animal holds fast to the intestinal wall. Thousands, or even tens of thousands, of eggs may be produced by a single joint. The joint is liberated when the eggs begin to ripen, often before. In some species several adjacent joints are pinched off at the same time. The tapeworm joints leave the intestine of their host either alone or with the dung. After falling to the ground they creep along like snails, and attach themselves to various plants. It is obvious that a tapeworm joint or a number of the eggs produced by it may easily be taken up by a grazing animal. The eggs of a particular kind of tapeworm are only able to develop further if they reach the intestine of a particular kind of host. It is undoubtedly true that, as a rule, only a relatively small number of the eggs produced by a tapeworm develop further, but the great powers of reproduction prevent the species from dying out. If, now, either a joint or the eggs from one are taken into the gut

of a suitable host, the joint and the egg-shells, or the latter only, as the case may be, are digested in the stomach or intestine, so that the larvæ are set free. These (Fig. 137) are spherical, glass-like, of microscopic size, as might be expected, and bear three pairs

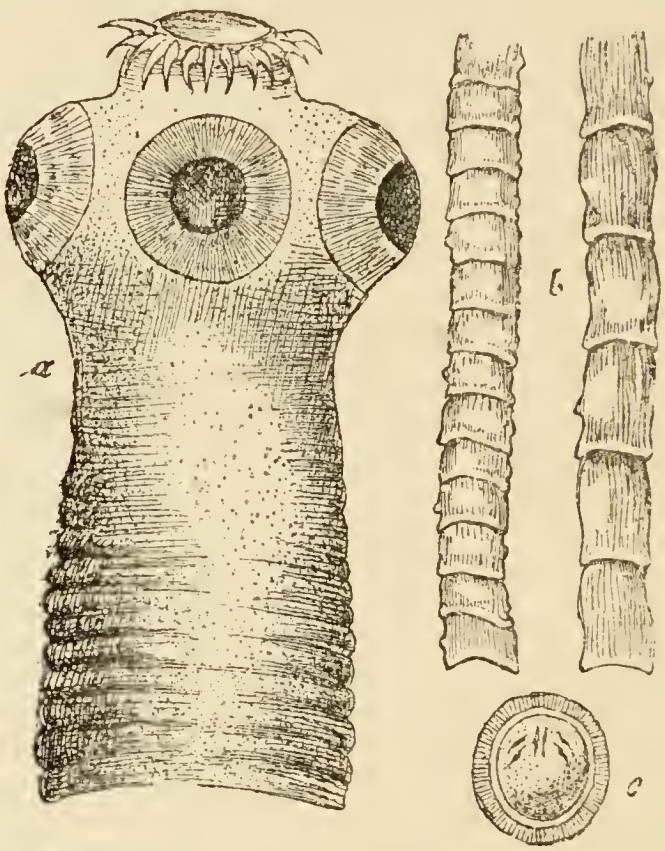

FIG. 136.—The Common Tapeworm (*Tænia officinalis*): *a*, head and neck, strongly magnified; *b*, joints, natural size; *c*, eggs, strongly magnified.

of hooklets, by means of which they quickly perforate the wall of the gut, and make a way through the tissues of the host. They may also be carried further by the blood-stream. The larva of a particular species settles down finally, not only in some particular kind of host, but also in some definite organ or tissue. It then loses its hooks, and is rapidly transformed into a hollow *bladder-worm* (measle), which grows till it reaches a definite size, depending on the species. Meanwhile it gradually develops one (*Cysticercus*) or several (*Cœnurus*) in-

FIG. 137. — Tapeworm Larva (of *Tænia solium*), much enlarged.

growths, or (in *Echinococcus*, Fig. 138) several new bladders are developed inside the bladder-worm, and ingrowths are usually formed within these, similar to those of the simpler kinds of bladder-worm. These ingrowths resemble tapeworm heads in all respects, possessing suckers, and, it may be, a circlet of hooks, but these are *inside*, and not *outside*.

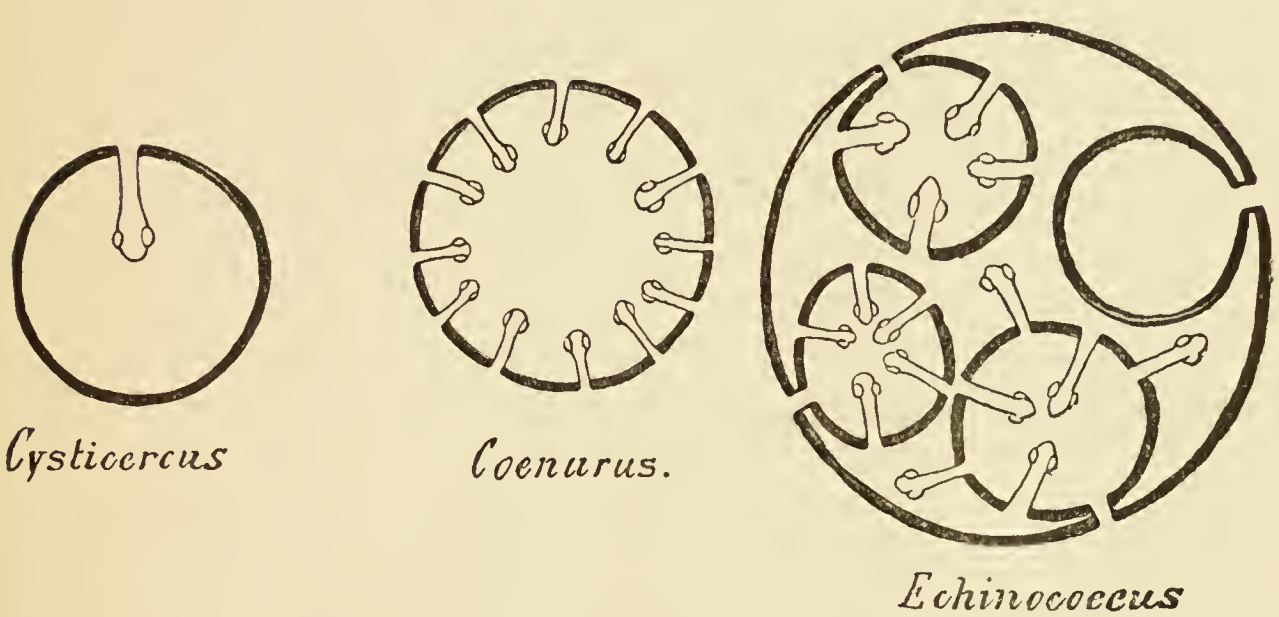

Fig. 138.—The three types of Bladder-worm, diagrammatically represented.

Later—either in the animal originally inhabited by the bladder-worm, or after it has been transferred in the flesh of this to the gut of some carnivorous animal—the bladder-worm contracts, so that it can no longer hold the fluid which is present, and the ingrowth is turned inside out, the suckers thus becoming external. The tapeworm head is formed in this way, but the bladder still remains attached to its hinder end (Fig. 139). If a host inhabited by bladder-worms is not devoured by another animal, the bladder-worms, after reaching their full size, remain for a long time in the same stage of development

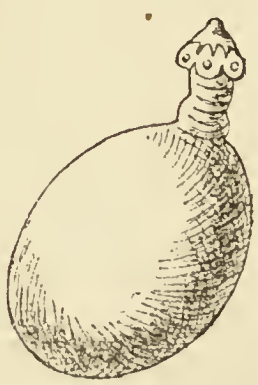

Fig. 139.—Measle of *T. solium*, with head thrust out (× 6).

without being able to develop further. But if the host is devoured by another animal, the bladder-worms enter its stomach and intestine, where the bladder is digested, while the tapeworm head remains uninjured. This thrusts out its suckers and attaches itself by means of them to the wall of the intestine, the process of joint-formation already described beginning soon afterwards.

The following tapeworms, which are important to the owner of stock, will be briefly dealt with.

The **Common** or **Armed Tapeworm of Man** (*Tænia solium*).

Six to ten feet long, with seven to eight hundred joints, and a circlet of hooks (Fig. 136), lives in the human intestine. Several of its sexually mature joints are commonly pinched off at a time, and if these are picked up from a field or dung-heap by a pig, the contained eggs develop into "pork measles" (*Cysticercus*, Fig. 140), which are especially abundant in

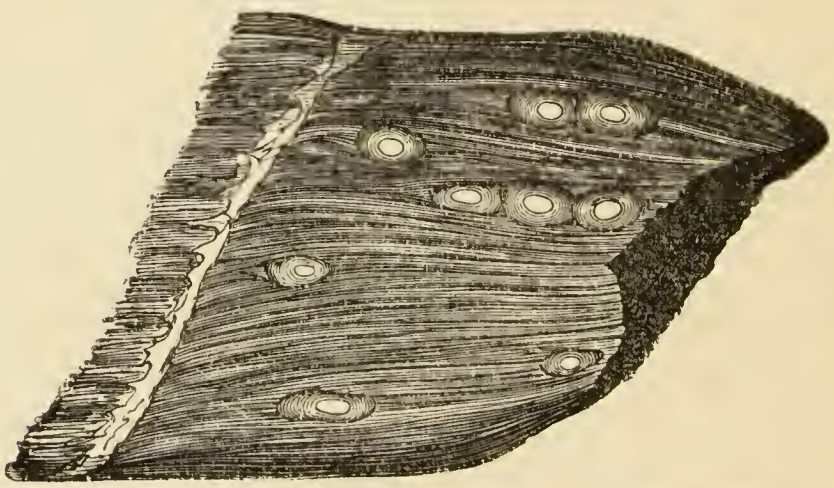

FIG. 140.—Measles in Pork; the white spot is the head (natural size).

the connective tissue between the muscles, and make the meat "measly." They may also occur in the connective tissue of other parts (fat, brain, spinal cord). Young pigs not more than six months old are most in danger of becoming measly. A tolerably large number of measles can be borne very well, but if very

abundant they cause emaciation, weakness, lameness, and poverty of blood. The flesh of an animal badly infested with measles may be pale, watery, or even greasy, while pork not so much diseased may seem all right, though it is really unfit for food, since if eaten in an insufficiently cooked state by human beings it would produce tapeworms. The measles are most abundant in the muscles of the breast and neck, and next to them in those of the hams and shoulders. From twelve to twenty thousand measles may be present in a single pig.

The **Unarmed Tapeworm of Man** (*Tænia saginata*) lives in the intestine of man, and, as a bladder-worm (*Cysticercus*), in the connective tissue of the muscles of the ox (and especially in the calf). It is from twelve to twenty feet, with as many as a thousand joints, but does not possess a circlet of hooks. The joints generally leave the intestine one by one, and creep on to grass and herbs, where they burst, so that the eggs are set free, and therefore get widely distributed. The ox scarcely ever takes in several joints of *Tænia saginata*, and consequently only a certain number of eggs. Beef never, therefore, contains so many measles as pork, and there is not a special measle disease of oxen. As, however, the eggs of *Tænia saginata* are more widely distributed, calves and oxen are more frequently infected with bladder-worms than is the case with swine.

The **Cœnurus Tapeworm of the Dog** (*Tænia cœnurus*) is the cause of the bladder-worm, producing sheep-gid, or sturdy (*Cœnurus cerebralis*). This tapeworm, which may live in the intestine of other animals besides the dog, has a circlet of hooks, is from fourteen to sixteen inches long, and consists of about two hundred joints. It generally lives in the intestine of the sheep-dog, in correspondence with which is the

fact that the bladder-worm lives in the brain of young sheep. If a sheep-dog harbours *Tænia cœnurus* in its stomach, a sheep may very easily take up a joint with grass or heath. The joint is then digested in the sheep's intestine, and the larva escapes from the egg. It bores through the wall of the sheep's intestine, gets into the circulation, and is carried by the blood-stream to various parts of the body; it can only develop further, however, in the brain (or spinal cord). After the minute larvæ have reached the cavity of the cranium they move about on the outer surface of the brain, and dig out channels there till they find a suitable place for further growth. The larva now becomes a bladder-worm, which gradually grows, until it attains a size varying from that of a nut to that of a hen's egg. It develops numerous tapeworm heads, even from three to four hundred. These become tapeworms if a sheep is killed by the parasite, and its head devoured by a dog or fox.

The disease caused by the presence of bladder-worms in the brain is called "gid," or "sturdy," also "staggers." Two stages can be distinguished in it. During the first period the symptoms of disease are chiefly due to the wounds which the larvæ make on the surface of the brain, and the consequent inflammation of the investing membranes. Even in this stage the disease may be fatal, but the symptoms cease as soon as the larvæ cease to move about. The bladder-worms are only able to do harm by the pressure they exert, which is small at first, though it gradually becomes greater. The first stage of gid manifests itself in late summer, the second in late autumn, winter, or spring, according to the rate at which the bladder-worms develop. The symptoms of the first stage are caused by the increased flow of blood to the brain and head generally, resulting from the irritation which the larvæ exert. (Head very hot. Eyes bloodshot. The sheep are sluggish but restless, and carry

their heads in a strange way, to one side, bent back, or turned up. They often run round in a large circle. There may also be gnashing of the teeth, foaming at the mouth, squinting, convulsive movements, and loss of consciousness.) The symptoms of the disease in its second stage are the result of pressure on the brain and some of the arteries of the brain and skull. (The sheep affected separate themselves from the others, and generally hang their heads. Gaze fixed. Occasional loss of consciousness. Movements strange; run or turn round in a circle. The sheep often staggers and falls to the ground. The bones of the skull become thinner at the place under which the bladder-worm is found, sometimes even as thin as paper.)

Remedies: Trepanning, as the bladders lie just underneath the roof of the skull. *Prevention:* Reducing the number of sheep-dogs; giving the dogs medicine to rid them of tapeworms in spring and summer; administering a specific to the yearling sheep in July and August, suitable for driving out any tapeworm larvæ which may be present in their intestines; *burning* (instead of *burying*) the heads of sheep affected with staggers which have died or been slaughtered. It is but rarely that all the larvæ living on the surface of the brain die between the first and second stages of the disease. A sheep affected by gid is therefore almost sure to die, and should be slaughtered as soon as possible. Compare "false gid," p. 189.

The **Minute Tapeworm of the Dog** (*Tænia echinococcus*) is at most scarcely one-sixth of an inch long, and consists of only three or four joints, often lives in large numbers in the intestine of the dog without injuring its host, but causes huge cysts (from the size of a pigeon's egg to that of a child's head) in the liver, lungs, or other organs of man, pig, and ruminants. These cysts are of the type represented

on the right of Fig. 138. They may prove fatal, owing to the pressure they exert in the organs containing them and the blood-vessels of the same.

The **Expanded Tapeworm** (*Tænia expansa*)

lives in the intestine of the ox, where it may attain the length of two feet, while in the intestine of the lamb it reaches at most the length of about nineteen inches. It is sometimes present in large numbers in lambs, causing difficulty of digestion with resulting emaciation, poverty of blood, and even death. Bladder-worm still unknown.

ORDER: **Trematoda** (FLUKES).

Flattened parasitic worms, tongue-shaped or leaf-shaped, living on or in a host, and provided with one or two ventral suckers. The intestine forks into two branches immediately behind the gullet, and these two divisions in some species (*e.g.* the large liver-fluke) branch again repeatedly in a tree-like fashion. Anus and blood-vessels absent. Almost all flukes are hermaphrodite; they fertilize themselves. All the forms living within a host (*i.e.* endoparasitic forms) lay an immense number of small eggs, from which larvæ are hatched that become asexually reproducing animals. These or their progeny produce once more the sexual form. The development is therefore an example of metagenesis (p. 16), but there is a change of host. Only the two liver-flukes need be dealt with here.

The **Large Liver Fluke** (*Distoma hepaticum*),

(Fig. 141), is flat, but swollen in the middle, when it contains a large number of eggs, under which circumstances the edges only are flat. The last are of a dirty brown colour, while the middle of the body is greyish yellow. There is a triangular projection at the front end of the body with a sucker at the apex,

and another at hinder end of the triangle. The outer surface of the body is covered with minute backwardly projecting spines, which present no hindrance to the forward creeping of the body in the bile-ducts, but make backward creeping or gliding impossible.

Eggs $\frac{1}{180}$ of an inch long, with a red shell possessing a greenish sheen. They can only develop if they get into water, and in wet years the conditions are very favourable on damp meadows, for under such conditions the sheep-dung, with the contained fluke eggs, is liable to fall into pools of water. But many of the eggs can develop in years that are not so wet and on dryer fields, as they may be carried into a ditch by rain or on the feet of the sheep. The larva hatched from the egg of the liver-fluke is $\frac{1}{125}$ of an inch long, elongated in shape, and swims about freely in the water by means of a covering of cilia (Fig. 142, *a*). It soon finds its way into the lung cavity of a small water snail (*Lymnæus truncatulus*, Fig. 142, *i*), loses its covering of cilia, and becomes broader, even almost spherical. In the free-swimming larva there are already to be found a collection of germinal cells in the hinder part of the body; later on, these cells repeatedly divide and form little heaps, which ultimately become fresh individuals. The larva has, therefore, passed into a second stage, and this is now known as a *sporocyst* (Fig. 142, *b*, *c*). The stage developed asexually from the heap of germinal cells is distinguished from the sporocyst by a differently shaped body and by the possession of a gut (with mouth, pharynx, and intestine, but no anus), which is absent in the latter. This stage is termed a "*redia*" (Fig. 142, *d*). From five to eight of them are usually

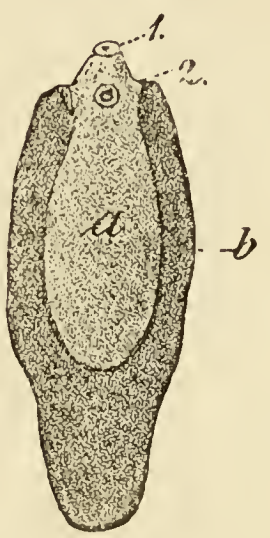

Fig. 141.—The Liver Fluke (*Distoma hepaticum*), natural size.

FIG. 142.—Liver Fluke: *a*, free swimming ciliated larva; *b*, young *Sporocyst*, a few days after migration into the snail; *c*, *sporocyst*, containing rediæ in various stages of development; *d*, *redia*, containing balls of germinal cells; *e*, mature *redia*, containing its brood of cercariæ; *f*, mature cercaria; *g*, just-encysted *cercaria*; *h*, young fluke, soon after entering sheep; *i*, the water snail, *Lymnæus truncatulus*.

a, *b*, *c*, *d* × 200; *e* × 150; *f* × 300; *g* × 150; *h* × 25; *i*, natural size and × 3¼.

developed within one sporocyst. Germinal cells are also present in the redia, and they develop into little heaps of cells from which, while the weather is warm, new rediæ are developed, that live in the lung cavity of the snail, like their parents. When the weather becomes colder, "*cercariæ*" (Fig. 142, *f*) are developed from the germinal cells, some fifteen to twenty of them within a single redia (Fig. 142, *e*). The cercaria has a long tail, by means of which it can propel itself in the water, after leaving the mother redia and the snail. It possesses two suckers, and a forked intestine without anus. After the cercariæ have moved about in the water for some time they fix themselves, by means of their suckers, to various plants growing in the water. The tail being now superfluous is lost, the cercaria becomes spherical, and contracts somewhat within an investment which it secretes (Fig. 142, *g*). When, later on, the pools in which the cercariæ live dry up, the plants which were before submerged are now on dry land, and may be devoured by sheep, together with the encysted cercariæ found upon them. The wall of the cyst is dissolved in the intestine of the sheep, and the contained cercaria gradually becomes a young liver-fluke, which at first is oval and very small (Fig. 142, *h*), while, later on, its anterior third becomes the triangular projection at the front end of the adult fluke, and its posterior two-thirds grow very considerably. Meanwhile the young liver-fluke has travelled from the intestine of the sheep into its bile-ducts. It appears that the fluke is completely grown within a few weeks after its introduction into the body of the sheep. Infection almost always takes place in summer or autumn. The life history of the liver-fluke exemplifies change of host and metagenesis (p. 16). From the egg of a sexual worm a free-swimming larva is developed, which becomes an asexual *sporocyst* within the snail. This sporocyst produces asexual *redicæ*, and from

these, also asexually, are developed *cercariæ*, which leave the snail, pass into water, attach themselves to plants, and reach the intestine of the sheep later on. The cercariæ become flukes by a process of metamorphosis, and are to be regarded as fluke larvæ.

It is easily explained why the "fluke disease," or "liver rot," caused by the fluke should appear much oftener in some regions than others. Low-lying pastures which are now and then flooded are best suited for the development of the disease, since the fluke eggs have a better chance of developing upon them. This is because at certain times of the year there are in such spots numerous submerged plants on which *cercariæ* encyst, and which, later on, when the pools dry up, are nibbled by sheep. It seems that the *cercariæ* mostly attach themselves to certain kinds of plants, hence the local nature of the disease, which of course also depends on the presence of *Lymnæus truncatulus* (Fig. 142, *i*).

Fluke disease first makes itself apparent in the sheep one or two months after infection. If the sheep does not die the parasites often remain in its liver till the next spring. The liver of a single sheep may contain from 200 to 250 individuals. They live in the various branches of the bile-duct, and the irritation they set up first causes an unusual quantity of blood to flow to the liver. Inflammation and internal bleeding may result, and gall stones are deposited in the thickened walls of the biliary passages. The flow of bile from the liver is made difficult or impossible. Later on, the parasites draw so much blood from the liver that this organ is very insufficiently nourished, so that no more bile is secreted, and the liver substance shrivels up. In consequence of these changes the digestion is incomplete, and the whole body of the sheep is very insufficiently nourished. The diseased sheep are therefore sluggish and enfeebled; they eat little, but drink a great deal, and suffer from poverty

of blood. Their wool gets dry, and does not hold together, and they become emaciated. Dropsy and diarrhœa set in, and jaundice often makes its appearance. If a sheep is infested by a tolerably large number of flukes, death is almost always the final result.

"The best *preventative* is a trustworthy and careful shepherd,"[1] who will not let the sheep feed in spots where previous experience shows the disease is usually contracted during damp summers. Furthermore, sheep badly infested should be slaughtered as soon as possible, so that the flukes they contain may not get to the egg-laying stage. Sick sheep should be fed with nourishing food (various kinds of hay, oats; with addition of cooking salt), so that young sheep containing but few flukes may get back their strength, while this treatment will make the badly infested sheep die more quickly.

Oxen are also frequently affected by fluke disease in many regions, other animals to a less extent.

The **Small** or **Lancet-shaped Liver Fluke** (*Distoma lanceolatum*)

is about three-eighths of an inch long, one-tenth of an inch broad, thin, and lancet-shaped. Lives, like the preceding kind, in the liver of the sheep. Development unknown.

Fourth Sub-Kingdom: **MOLLUSCA** (Molluscs).

This sub-kingdom, to which oysters, snails, cuttle-fish, etc., belong, includes unsegmented animals devoid of internal skeleton, and with bilaterally symmetrical (p. 16) embryo, while the adult may be much modified, especially in snails, which are enclosed in spiral shells, and also have their bodies partially coiled. The skin of molluscs possesses a peculiar and characteristic

[1] Spinola.

covering. From a definite part of the body a larger or smaller fold of skin ("mantle") grows out, which encloses a space termed the "mantle cavity," and also, from its function, the "respiratory cavity." In most molluscs this mantle secretes an external or internal calcareous mass. In this way a "shell" is developed (Fig. 143, A, *S*), which is usually external. This is the case, for example, with the edible, or Roman snail, and the common garden snail. In other cases (cuttlefishes), the shell is formed inside the mantle, or it

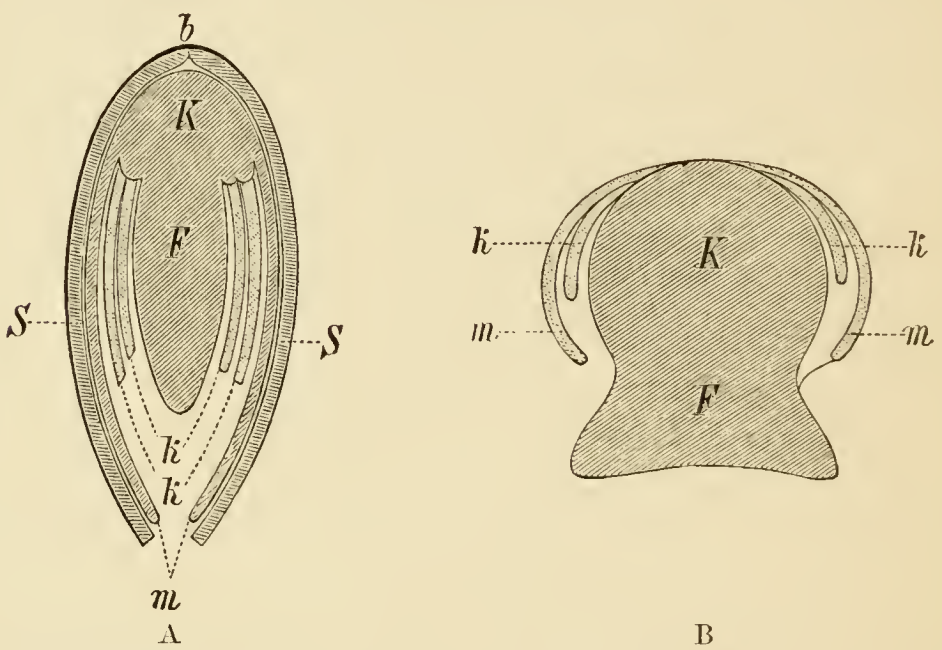

FIG. 143.—Diagrams to explain the form of the body of a Mollusc. A, a Bivalve Mollusc; B, a Snail (cross sections). In both; *K*, body; *F*, foot; *S*, shell; *m*, mantle; *k*, *k*, gills.

may be replaced by a collection of calcareous granules (various slugs). In most molluscs the chief organ of locomotion is the so-called "foot" (Fig. 143, *F*). This is a very muscular region of the body, covered by skin, and serving either for crawling (snails), or else for digging in the sand, and even springing (bivalve molluscs). Its structure varies according to its function. I mention three classes, those of *Cephalopoda* (Cuttlefishes), *Gastropoda* (Snails and Slugs), and *Lamellibranchiata* (Bivalve Molluscs).

CLASS: **CEPHALOPODA** (CUTTLE-FISHES).

The head is sharply marked off from the rest of the body, and the mouth is surrounded by a circle of arms bearing suckers or claw-like hooks. These arms are supposed to be a modification of part of the foot, the rest of this organ being constituted by a hollow, funnel-shaped structure, which places the mantle-cavity in communication with the exterior. The water used for respiration is forced suddenly out from the mantle-cavity, through the funnel, so as to propel the animal in the opposite direction. A gland, known as the "ink sac," secretes a brownish fluid, which may be pressed out of the sac so as to shield the animal from attack. All cephalopods are marine, and, since they are therefore of no agricultural importance, it is unnecessary to enter into details regarding their form and structure, and I will only mention the following: **Pearly Nautilus** (*Nautilus pompilius*), with external shell and numerous arms; **Paper Nautilus** (*Argonauta argo*), with a very thin, boat-shaped shell, and eight arms; **Poulpe** (*Octopus*), without shell, and with eight arms; **Cuttle-fish** (*Sepia*), and **Squid** (*Loligo*), also without external shell, and possessing ten arms.

CLASS: **GASTROPODA** (SNAILS AND SLUGS).

Snails and slugs possess a head which bears unjointed tentacles, and also eyes, which, in many cases, are borne on the tips of these. The foot serves for creeping, and is flattened in a sole-like way on its under side. The mantle is generally small, and limited to the dorsal side of the animal. The usually spiral shell covers therefore only a small part of the body, but the rest of the body can also be mostly or entirely drawn back into it. Snails possess jaws, but the

chief organ used in attacking the plant structures is the swollen tongue, covered by a rasping plate (radula), on the surface of which regular rows of teeth are arranged. The rest of the tongue consists of muscle, and two small cartilages are also found within it. The teeth stick up when the tongue is protruded, and the whole apparatus forms a kind of rasp, by the backward and forward movements of which the food is reduced to small fragments. Marine snails breathe by gills, which are found in the mantle-cavity, while most of the freshwater and all the land forms ("Pulmonata") breathe by means of the inner wall of the mantle-cavity, which thus serves as a lung. Some members of the group are hermaphrodite, while the sexes are distinct in others; the first is the case in all terrestrial forms. Such snails pair, however, mutually fertilizing each other. They are not able to fertilize themselves. It is only among land snails and slugs that injurious kinds are found. Species of the genus *Helix, e.g.* the **Edible** or **Roman Snail** (*H. pomatia*) and the **Field Snail** (*H. nemoralis*), may do harm in fruit-culture; **Slugs** are very injurious to agriculture (*Limax* and *Arion*); in Limax, the respiratory opening is situated behind the middle of the right margin of the mantle, while the genital opening lies behind the right feeler; in Arion, the respiratory opening is situated on the front edge of the mantle, and the genital opening immediately in front of it. Any kind of snail or slug may be harmful, especially if it attacks young plants. Some kinds, however, live chiefly in woods, feeding upon toadstools and dung, perhaps also on bark and weeds (*e.g.* dandelion). This is especially true of the larger kinds, but these too, if they multiply very rapidly, may effect much damage in gardens and fields. The commonest slugs are—

The **Common Black Slug** (*Arion ater*).—About four inches long, and generally black.

The **Grey Field Slug** (*Limax agrestis*, Fig. 144).—

Four-fifths of an inch long, small and smooth, with dark tentacles, grey back, often a reddish sheen, and bright grey or white under side.

The **Large Slug** (*Limax maximus*).—Up to six inches long, with black flecks on the hump-like mantle, and black streaks on the rest of the body.

In a large majority of cases where slugs appear to an injurious extent, the grey field slug is the offender, and I will therefore deal with it in greater detail. What is said regarding the small species, however, may be taken to apply to all the other kinds, should they become a pest.

The **Grey Field Slug** (*Limax agrestis*).

The life of the grey field slug is very dependent on moisture. During dry weather it rolls itself up and hides in the ground, under a stone, or in some such

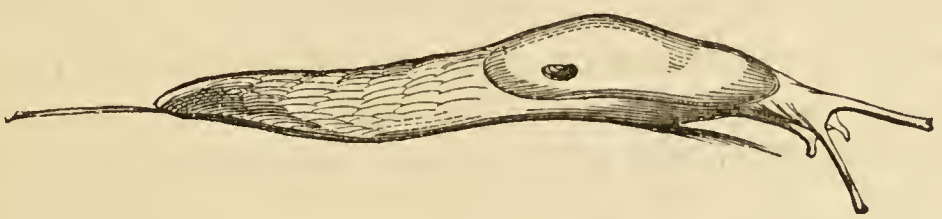

FIG. 144.—The Grey Field Slug (*Limax agrestis*).

place, where it is protected as much as possible from completely drying up. At such times it only comes to the surface to feed at night, but does so during the day as well when the weather is wet. The field slug is very destructive in fields and gardens, but this is only the case in those years the great dampness of which is specially favourable to its continuance and multiplication. The glassy eggs are laid in heaps containing from six to fifteen, in damp concealed spots in the ground, under moss, grass, etc., during August, September, and even October. A single slug may lay as many as four hundred. The eggs are able to withstand extreme cold and extreme dryness, and moisture makes them swell out again if they have shrivelled

up. In warm, damp weather the young slugs (which are one-twelfth of an inch long in the contracted, and two-fifths of an inch in the extended condition) hatch out in three or four weeks. Cold weather retards the development. If the weather is favourable, and suitable food is not wanting, they are often almost full-grown in six weeks' time. It is clear, from the foregoing, that in damp years the slugs may appear in very large numbers, especially in autumn; but it may also happen that most of the young slugs hatch out the following spring, in which case the greatest amount of damage will be done then. A snail may live several years, spending the dry days and the whole of the cold season in the ground or some other sheltered place. These slugs devour by preference delicate leaves and stems; young grain, young clover plants, leaves of rape, cabbage, turnips, and lettuce are their favourite food, also fallen fruit, strawberries, cucumbers, and vegetable marrows. *Preventive Measures:* Protection of their natural enemies: pigs, moles, shrews, ducks, fowls, pigeons, rooks, starlings, toads. Draining the soil, as slugs flourish most where it is moist. Sowing the winter grain as soon as possible, as the young plants will then probably have attained a fair size when the slugs appear in force. *Remedies:* Collection. The slugs readily crawl on to bits of cucumber or turnip which are thrown down, and can then easily be collected, or killed with quicklime. All substances which readily absorb water kill slugs by taking from them the moisture which is necessary for their existence. Cooking-salt, unslaked and slaked lime may be employed for this purpose. It seems to me most convenient to use freshly slaked lime, ten to twelve bushels per acre. Since the lime can only kill the slugs when it comes into contact with their skins, it must always be strewn on the land at a time when they are on the crawl, not later than 8 a.m., and only in dry weather. As soon as the

slugs are touched by the lime they begin to give out a great deal of slime, and many of them, especially the younger ones, are killed and become black. Very many of the older slugs, however, escape death, since the tenacious slime they give out, when the lime touches them, forms a continuous coat like a cocoon, out of which the slug creeps, now much poorer in water. It is therefore a good plan to strew powdered lime over a slug-infested field twice in succession, leaving an interval of some ten or fifteen minutes. The second strewing brings the lime into contact with those slugs which have just crawled out of their slimy investment in a desiccated condition. They are unable to form a second coating of slime, and if touched for this second time with even the smallest particles of lime they at once contract and die. If a double strewing is repeated very early on the following morning, no slugs will be left alive on the field so treated.

CLASS: **LAMELLIBRANCHIATA** (BIVALVE MOLLUSCS).

Headless. The mantle consists of two flaps, which secrete two shelly pieces (valves) movably united on the dorsal side (Fig. 43). The foot is usually wedge-shaped. Respiration effected by gills placed in the mantle-cavity, which communicates with the exterior either by the usual respiratory opening, or by a breathing-tube (siphon). Most species are marine, but some live in fresh water. No kind is of agricultural importance. To this class belong the **Oyster** (*Ostrea edulis*), the **Sea Mussel** (*Mytilus edulis*), the tropical **Pearl Mussel** (*Meleagrina margaritifera*), the freshwater **Swan Mussel** (*Anodonta cygnea*), the notorious **Ship Worm** (*Teredo navalis*), etc.

Fifth Sub-Kingdom: ECHINODERMATA (Hedgehog-Skinned Animals).

The echinoderms are radially symmetrical, *i.e.* a number of similar parts which together make up the body are arranged around an axis (Fig. 145). These animals are usually five-rayed. The mouth lies at lower end of the axis of the body. In some echinoderms the radial symmetry is indistinct, and at the same time there is a more or less clear bilateral symmetry (p. 16). The dermal skeleton either consists of numerous microscopic calcareous deposits, or of firm plates; the skin often bears spines, hence the

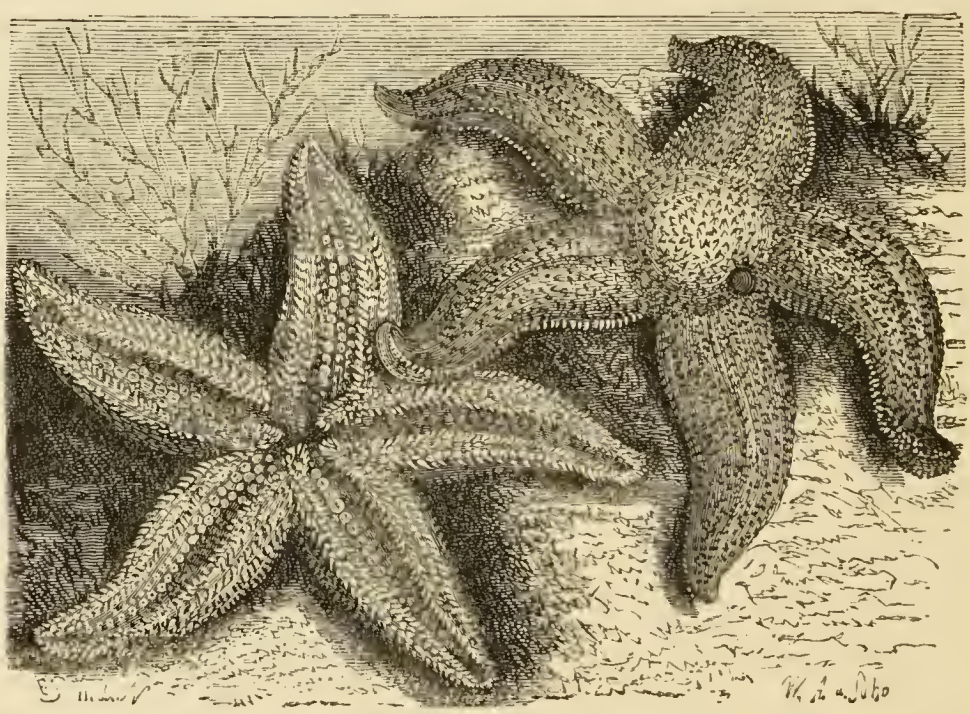

Fig. 145.—The Common Starfish (*Asterias rubens*), seen on the right from above, on the left from below.

name of the group. Echinoderms move by means of rows of tubular feet, which are connected with a water-vascular system, and are protruded by means of small bladders, connected with the same system, which contract and force water into them. The form of the body is apple-shaped to spherical (**Regular Sea Urchins**), shield- or heart-shaped (**Irregular Sea**

Urchins), pentagonal to star-shaped, with arms of varying length (**Starfishes**), or cylindrical to vermiform (**Sea Cucumbers**). All echinoderms are marine, and none of them, therefore, are of agricultural importance, though near the coast starfishes are sometimes used as manure.

Sixth Sub-Kingdom: CŒLENTERATA (ZOOPHYTES).

With a few exceptions the zoophytes are radially symmetrical (p. 252), and four-, six-, eight-, or many-rayed. They consist of a body-wall enclosing a cavity which, in the simplest forms (Fig. 146), is sack-like, but in several of the higher sub-groups divided up, and serves, not only for the reception and digestion of food, but also for the circulation of the digested food. Many zoophytes develop hard parts in the walls of their bodies, which remain after their death. The red coral used for ornamental purposes is of this nature, and so also are the coral islands which polypes build up. With the exception of the sponges, which are usually reckoned as belonging to this sub-kingdom, these animals possess "nettling organs" with which they kill their prey, and by which they are protected from attack. They reproduce by eggs, and most of them by means of budding as well (Fig. 146). In many species the buds are not detached as in the Freshwater Polype (*Hydra*), but remain attached so that a "colony" is formed. There are also free-swimming cœlenterates, known as jellyfishes or medusæ (Fig. 147). Many of these lay eggs which do not develop into fresh medusæ, but into polypes, which increase by budding to form colonies, on which medusæ are once more developed as buds. There is thus an *alternation of generations* (p. 16), in which the medusæ represent the *sexual* and the polypes the *asexual* stage.

Almost all zoophytes live in the sea, but some few in fresh water; none are important agriculturally. The following belong to this sub-kingdom: 1. The **Hydroid Zoophytes** (*Hydrozoa*), including the medusæ

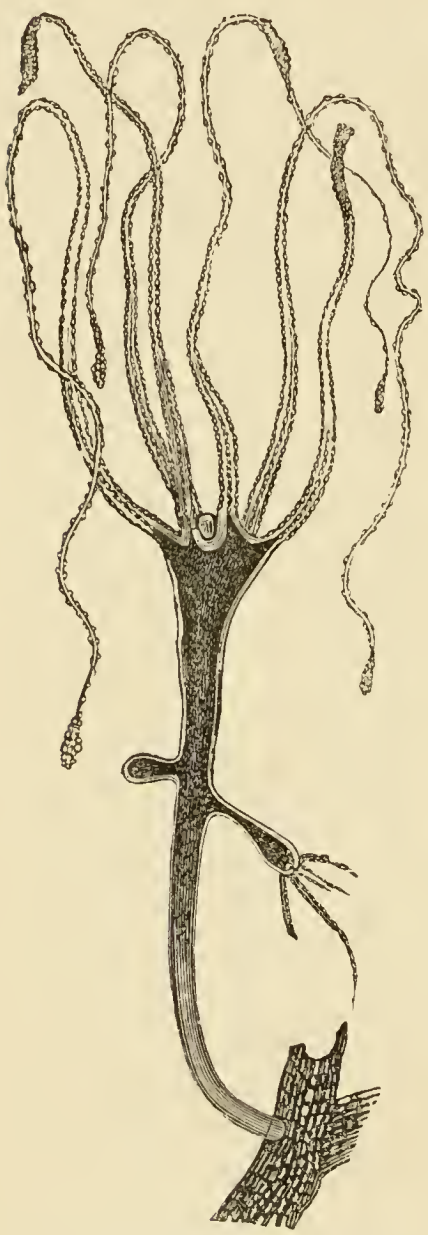

Fig. 146.—Fresh-water Polype (*Hydra*), bearing two buds of different ages. Highly magnified.

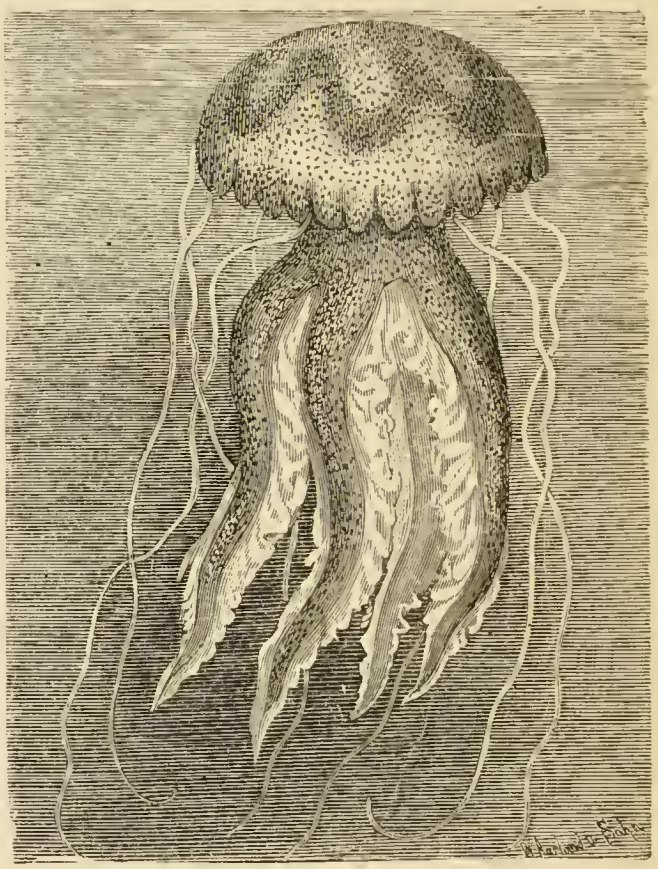

Fig. 147.—A Phosphorescent Jelly-fish (*Pelagia noctiluca*), ½ the natural size.

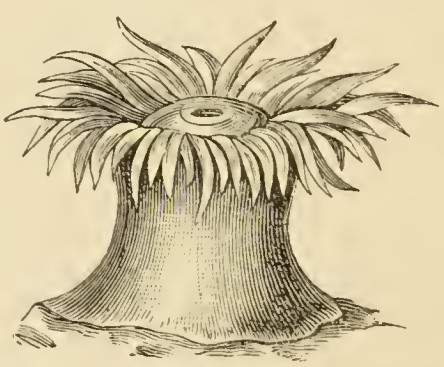

Fig. 148.—A Sea Anemone (*Sagartia nivea*).

of the North Sea, many of which are the sexual stage in the life history of fixed asexual *polypes*. The common **Freshwater Polypes** (*Hydra viridis, fusca,* etc.). 2. The **Flower Polypes** (*Anthozoa*), to which

belong **Red Coral** (*Corallium rubrum*), and the **reef-building corals** (*Astræa, Mæandrina,* etc.). 3. The **Sponges** (*Porifera*), which are usually considered cœlenterates, though they possess no nettling organs (**Freshwater Sponge** = *Spongilla,* **Bath Sponge** = *Euspongia officinalis*).

Seventh Sub-Kingdom: PROTOZOA

(One-celled Animals).

This sub-kingdom includes animals which are mostly microscopic, or at any rate small, and live in the sea, fresh water, or damp places. They are unicellular, and consist of a soft viscous substance (*protoplasm*

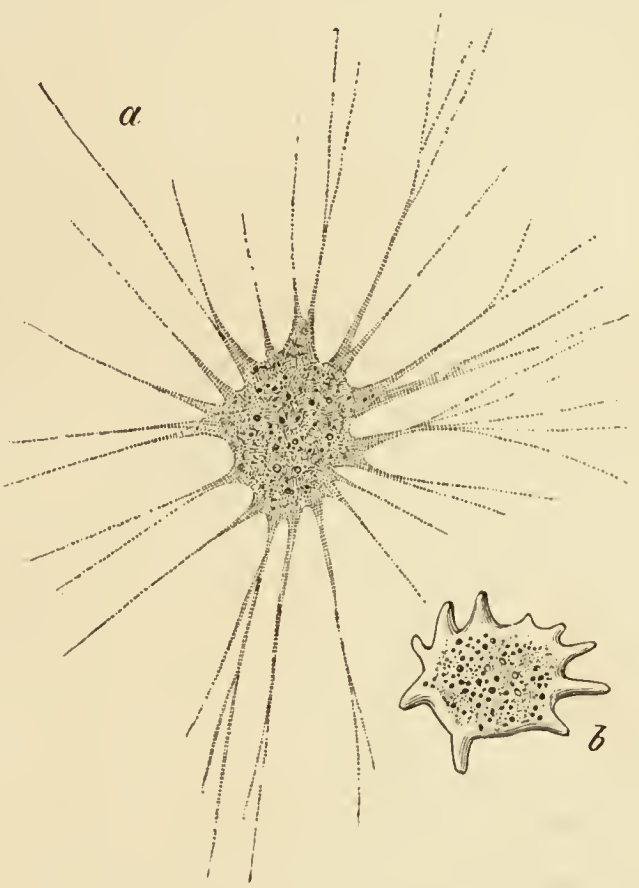

Fig. 149.—Two species of Proteus Animalcule (*Amœba*), one with protoplasmic processes, slender and branched; the other with short blunt processes. Highly magnified.

or *sarcode*) of contractile nature, and therefore capable of altering its shape. They may or may not be enclosed by a firm wall. Many secrete siliceous

structures or calcareous shells. They are of no agricultural importance. Here belong: **Infusoria**, common in putrid solutions; and **Rhizopods**, such as *Amœba*, the **Proteus Animalcule** (Fig. 149), so called because its shape is constantly altering.

THE END.

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